A Health Outcomes Resource Standard (HORSt) for Australian State Public Health Funding Distributions

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Submitted in fulfilment of the requirements for the award of the degree

Doctor of Business Administration

2019

This research has been conducted with the support of the Australian Government Research Training Program Scholarship

Faculty of Business

UNIVERSITY OF WOLLONGONG

December 2019

ABSTRACT

Australia is a federation with a mixed private-public system. Public hospitals and community health care are the responsibility of states and territories. Private fee-for-service clinicians and pharmaceuticals is subsidised by the Commonwealth government via the Medicare Benefit Schedule (MBS) and Pharmaceutical Benefits Scheme (PBS). As with other countries, issues of efficiency and equity are key considerations, with equity issues in Australia confounded by large geographical area and population distribution.

This study presents a quantitative tool to improve resource distribution for state public health systems that provide public hospital and community services. The goal is to enable improvements in health outcomes, promote allocative efficiency and improve equity between geographical regions. A Health Outcomes Resource Standard (HORSt) is a new population needs-based funding tool that can inform resource distribution from Australian states to Local Health Networks (LHNs). The aims of the HORSt are to:

1. Have a parsimonious, measurable and consistent benchmark of desirable health outcomes approximated by health status for states' LHNs' populations relative to funding inputs across the continuum of care.
2. Identify and incorporate measures of local geographical population health needs into resource allocation decisions.
3. Identify the share and quantum of taxpayer resources provided by the state to geographical populations to maximise equity of health funding across the continuum of care.

The HORSt identifies what the relative share of state health funding should be from the state health budget for each local population on the basis of need, after Medicare and Pharmaceutical benefits (Commonwealth public subsidies) are considered. The HORSt is a tool of outcomes-based commissioning. The HORSt is intended to be the first step in a broader state health funding model to inform resource distribution to LHNs, utilising activity-based funding (ABF) as it is presently used for purchasing facility outputs and a driver of technical efficiency as the second step. This study uses NSW as a case study.

The HORSt utilises age-standardised Potential Preventable Hospitalisations (PPHs) within populations as a marker of population health status and proxy of the wellbeing and health outcomes of the local populations. The HORSt utilises Two-stage Data Envelopment Analysis (DEA) to first assess the allocative efficiency of the main publicly provided resources across the continuum of care

amongst 88 small population areas across NSW, to produce benchmarked low (desirable) levels of age-standardised PPHs. Regression analysis is utilised in the second stage in order to explain the allocative efficiency for each small population via considering populations' social determinants of health.

Predicted allocative efficiency scores for each small area population and the LHNs that they reside within are then calculated from the regression equation. Health need indices are developed from these predicted scores relative to their distance from the benchmarked level of allocative efficiency. The need indices applied to the pool of publicly subsidised funding across the continuum of care then inform the share of state health funding that ought to be provided to each LHN, to act as a financial enabler to address populations' needs arising from social determinants that influence populations' health status.

HORSt DEA produces meaningful results for each region's measured allocative efficiency of health outcomes taking into account the use of MBS, PBS and state health resources. Populations with the best and worst health outcomes are amongst those with the highest and lowest rates of allocative efficiency respectively. The findings from the regression stage successfully predict the measured allocative efficiency of the DEA, indicating that the most advantageous and disadvantageous social determinants give rise to the best and worst levels of allocative efficiency of health outcomes. Significant predictors of each population's allocative efficiency of health outcomes are: socioeconomic status; the proportion of the population who are indigenous; and the proportion of the population who pay out-of-pocket costs (proxy for private service utilisation).

HORSt represents a departure from the standard approach of population needs-based funding models that have sought to use predictors of utilisation for informing resource distribution, adopting a risk capitation approach to health needs. Whilst these models do have their place, the HORSt demonstrates a viable alternative where enabling equity and improving health outcomes is the key goal for resource distribution. Population health needs in this context can be better assessed via considering the measurement of allocative efficiency of a suitable proxy of health outcomes and by considering the productivity of resource inputs across the continuum of care. Traditional models make no attempt to consider the productivity of the resource inputs across the continuum of care and therefore make no attempt to measure allocative efficiency of health outcomes. If the goal of all health systems is to ultimately improve health outcomes, funding acting as an enabler to do so is better served by a HORSt to guide resource distribution that makes allocative efficiency and the determinants for achieving it or restricting it obvious.

ACKNOWLEDGEMENTS

This journey at times has been lonely, fatiguing and frustrating. The journey has involved sacrifice with early morning finishes, limited sleep towards early morning starts for work and endless weekends and nights that have been consumed over the last five years. Whilst I have laboured over every stage, the support and care of many has been the fuel to help this process succeed.

To my supervisors Professor Kathy Eagar, Director of the Australian Health Services Institute and Dr Silvia Mendolia, Centre for Human and Social Capital Research, thank you both for your patience, kindness, expertise and generosity. I could not have asked for a better team to steer me in the right direction.

The decision to ultimately select the DBA program over a traditional PhD has afforded myself with a greater degree of practical research skills that translate directly to business. Whilst the rigours and standards of both qualifications' thesis are the same, I am deeply grateful for the learning and research training that the concurrent advanced course work in the first two years of the program offered. To this I profoundly thank: Professor Grace McCarthy, Dean, Sydney Business School; Professor Nina Reynolds, School of Management, Operations and Marketing; and Associate Professor Nelson Perera, Head of School, School of Accounting, Economics and Finance; for your expertise, input, patience and guidance.

The application for Data Envelopment Analysis that I utilised to progress this thesis has been greatly enhanced by the time afforded to me by Dr Amir Arjomandi from the University of Wollongong Economics - School of Accounting and Finance. I am very grateful for the time you took to add value to the econometrics development that I have been able to achieve.

I also wish to acknowledge Lauren Richardson at Sydney Business School library. Thank you for your patience and assistance, particularly in the early days of the research.

For my family this journey has been difficult. For my wife Pauline, the study is something that has impacted both of us. Thank you for the support in believing in this journey. The last twelve months have been very hard on us. I'm looking forward to our team jettisoning the burden of this time and stress bandit and focusing more on fun. Thanks for your care, love and support.

To my children Vivienne and James, you are the two greatest blessings in my life. I have tried to balance my time with you against the backdrop of work and this thesis. This has been a difficult juggle and I am so looking forward to having much more free time to spend with you.

To my father and sister, thanks for always finding words of positivity. Thank you for taking a keen interest in my progress at all stages and encouraging me along the way. There's bits and pieces of you both in the fuel of this study. Dad you tirelessly managed your corner of the public health system for many years. You know only too well that reform does not come easy and that some of the best change comes from being a quiet and resilient achiever. Persistence is what you instilled in me at a very early age and persistence is what this journey has required. Cathy you have shown me over the years the power of words and the responsibility behind them. I'm glad I can share the end of this journey with you both.

Whilst my mother never knew of this journey, there have been many times over the last five years that I could hear her words of encouragement that she instilled upon me as a child; to never stop anyone from letting you learn and never let anyone be a barrier to allowing you to succeed at worthy causes. In part this thesis has been further inspired by my mother who whilst suffering multiple connective tissue and circulatory diseases that ultimately left her profoundly disabled, never ever gave up. Her tenacity to survive and make the best of things, made her by default the expert health consumer. She knew too well the siloed barriers of health care and the payment system in Australia that when fractured can lead to people falling through the cracks. Mum, in no small part this thesis is dedicated to you.

To my colleagues within the health system, Associate Professor Josephine Chow, Catherine Katz, Liz Hay, Susan Burke, Mahendra Sharan, Andrew Marshall, Ross Sinclair, Jorida Zeneli, Elena Venuti thank you for standing by me and supporting this work. To my DBA and integrated PhD colleagues, Simone Sietsma, Louise Brockbank, Kevin Singh, Suzi Skinner, thanks for sharing the ride.

To Susan "Penny" Palese, my great friend of more than two decades. Thanks for being consistently always there – be it mainly from the other side the world. Nonetheless you were there always when it mattered.

To Phil Windsor, the best of friends, my Jerry Maguire, you instil integrity and wisdom in all that you do. You were always there. A champion amongst many. My profound gratitude to you for always having my back, always being interested, always listening, always supporting.

There are numerous other friends that despite either distance or lack of my active involvement with you socially due to this study's unrelenting capture of my time have made the time to check in with me nonetheless. For this I am most grateful. Thank you.

To my former colleagues and those who pioneered the former NSW RDF and RAF models and gained bipartisan support for these models across governments of all political bents: an enormous thank you. This work stands upon the shoulders of your efforts. I humbly make this contribution.

CERTIFICATION

I, John Slater, declare that this thesis submitted in fulfilment of the requirements for the conferral of the degree Doctorate in Business Administration, from the University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

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ABBREVIATIONS

ABC	Australian Broadcasting Commission
ABF	Activity Based Funding
ABM	Activity Based Management
ABS	Australian Bureau of Statistics
ACSC(s)	Ambulatory Care Sensitive Condition(s)
ACSQHC	Australian Commission on Safety and Quality in Health Care
ACT	Australian Capital Territory
AHCA	Australian Health Care Agreement
AHS	Area Health Service
AHSRI	Australian Health Services Research Institute
AIHW	Australian Institute of Health and Welfare
AMA	Australian Medical Association
ANOVA	Analysis of Variance
ARIA	Accessibility and Remoteness Index of Australia
ASGC	Australian Standard Geographical Classification
ASGS	Australian Statistical Geography Standard
ATSI	Aboriginal and Torres Strait Islander peoples
BMA	British Medical Association
CGC	Commonwealth Grants Commission
CRS	Constant Returns to Scale
CSO	Community Service Obligations
DBA	Doctor of Business Administration
DEA	Data Envelopment Analysis
DMU(s)	Decision Making Unit(s)
DRG	Diagnosis Related Group
DRS	Decreasing Returns to Scale
EHUI(s)	Expected Health Utilisation Index / Indices
GFC	Global Financial Crisis
GST	Goods and Services Tax
HNI(s)	Health Needs Index / Indices
HORSt	Health Outcomes Resource Standard
HREC	Human Research Ethics Committee

ICD	International Statistical Classification of Diseases
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification
IEO	Index of Education and Occupation
IER	Index of Economic Resources
IHPA	Independent Hospital and Pricing Authority
IRS	Increasing Returns to Scale
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
IRSD	Index of Relative Socio-economic Disadvantage
LGA(s)	Local Government Area(s)
LHD(s)	Local Health District(s)
LHN(s)	Local Health Network(s)
MBS	Medicare Benefits Schedule
NAP(s)	Non-Admitted Patient(s)
NAPLAN	National Assessment Program—Literacy and Numeracy
NDIS	National Disability Insurance Scheme
NHMRC	National Health and Medical Research Council
NHRA	National Health Reform Agreement
NHS	National Health Service
NSW	New South Wales
NT	Northern Territory
NWAU	National Weighted Activity Unit(s)
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
OOP	Out-Of-Pocket costs
PBAC	Pharmaceutical Benefits Advisory Committee
PBS	Pharmaceutical Benefits Scheme
PHI	Private Health Insurance
POP	Population
PPH(s)	Potentially Preventable Hospitalisation(s)
PPP	Purchasing Power Parity
PREM(s)	Patient Reported Experience Measure(s)
PROMS	Patient Reported Outcome Measure(s)
QALY(s)	Quality Adjusted Life Year(s)

QLD	Queensland
QRAF	Queensland Resource Allocation Formula
RAF	Resource Allocation Formula
RAWP	Resource Allocation Working Party
RDF	Resource Distribution Formula
SA	South Australia
SCR(s)	Standardised Cost Ratio(s)
SAPHaRI	Secure Analytics for Population Health Research and Intelligence
SEIFA	Socioeconomic Indices for Areas
SMR	Standardised Mortality Ratio
SNAP	Sub-Non-Acute Patient
SRS	School Resourcing Standard
SWSLHD	South West Sydney Local Health District
TAS	Tasmania
USA	United States of America
USD	United States Dollar
VFI	Vertical Fiscal Imbalance
VIC	Victoria
VIF	Variance Inflation Factor
VRS	Variable Returns to Scale
WA	Western Australia
WHO	World Health Organisation
WIES(s)	Weighted Inlier Equivalent Separation(s)

CHAPTER ONE - INTRODUCTION

1.0 INTRODUCTION

This study presents the development of a Health Outcomes Resource Standard (HORSt), a resource allocation instrument and equity monitor designed to address health inequities evident in geographical populations' health status and guide more equitable resource distribution of Australian states'[1] public health funding to their Local Health Networks (LHNs)[2], so as to improve health outcomes of populations. This is a quantitative econometric study that uses the state of New South Wales (NSW) in 2015/16 as a case study to demonstrate the model.

The current payment[3] model employed by states to fund public health services at the local level is Activity Based Funding (ABF) (Independent Hospital Pricing Authority 2015a). ABF by definition as a casemix / episode funding model that pays for hospital outputs, informs the comparative technical efficiency of facilities outputs across LHNs (Broadhead 1991; Eagar et al. 2001). However, whilst all states have embraced ABF as a new payment currency for purchasing hospital activity since Commonwealth[4] health reforms required it from 1 July 2012 (Council of Australian Governments 2011, p. 64; Palmer & Short 2014, p. 108), ABF by its design, is an output-based funding instrument useful for driving technical efficiency. By design, it does not aim to promote allocative efficiency or address health inequities that are evident in Australia, such as avoidable illnesses and premature deaths (Australian Institute of Health and Welfare 2016b).

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[1] Throughout this thesis, the term 'state' means any Australian state or mainland territory of Australia.

[2] Regionalised Health Services in states have various different names. In New South Wales, they are known as 'Local Health Districts LHDs'; in Queensland 'Hospital and Health Services'; in South Australia 'Local Health Networks'; in Victoria Local Hospital Networks and in Tasmania 'Tasmanian Health Organisations' (Australian Institute of Health and Welfare 2016a, p. 26). **For brevity, this thesis uses the term 'LHN' to refer to states' regional population area health service structures.**

[3] In NSW the Ministry of Health (MoH) since the commencement of ABF describes the funding model as a "purchasing model". However, for all intents and purposes the NSW MoH model is a funding model. The MoH sets activity targets for every LHD that are ultimately then provided with funds to utilise on the agreed activity volume (Foley 2011, 2012).

[4] The term "Commonwealth" refers to the Commonwealth Government of Australia. The Commonwealth is also known as the Australian Federal Government, or the Australian Government.

This position has recently been articulated by the Independent Hospitals Pricing Authority (IHPA) that governs ABF pricing determinations. i.e.:
"Whilst Activity Based Funding models have been effective in driving technical efficiency in the delivery of public hospital services, the current pricing models designed by IHPA do not necessarily provide incentives to maximise allocative and dynamic efficiency" (IHPA 2019, p. 30).

Consequently, resource distribution by states to LHNs is not determined by technical efficiency considerations alone. This is evident by all states, whilst considering population growth, still relying somewhat largely on using historical determinants, typically previous years casemix activity, as the starting point in establishing funding distribution to LHNs so as to determine negotiated agreements with LHNs in relation to how much activity is to be funded (Department of Health and Human Services Victoria 2014; NSW ABF Taskforce 2013b; Queensland Health 2014; SA Department of Health and Ageing 2014; System Purchasing and Performance 2013; Western Australia Department of Health 2014). In the case of NSW, minor equity adjustments, (where population health needs are expressed as predictors of utilisation) are also made to this starting point (NSW Ministry of Health 2017, p. 50; 2018, p. 23). Once activity targets are established for each LHN, ABF is then used as the purchasing / funding model within this largely historically determined envelope.

The current funding model from state to regional / local area therefore is made up of two primary stages:

1. Cost / historical activity adjusted for population growth factors determines the funding envelope (activity targets) distributed from the State to LHN; and
2. ABF used to purchase facility-based services with the region/ local area.

Both stages ultimately focus on funding and purchasing outputs within the state health system. In doing so they do not consider the productivity contributions and allocative efficiency of publicly subsidised funding inputs across the continuum of care within Australia's mixed private / public health system for achieving desirable health outcomes.

This thesis develops the HORSt not to be a comprehensive public health funding model for Australian states. The goal is the development of a tool that can be used by states as the first step in a two-step funding model as a population needs-based resource distribution enabler to promote equity and allocative efficiency.

Specifically, the HORSt as the first step will identify the total share of public funding that should be provided to each LHN from the state budget with respect to:

- the pool of public resources consumed by each LHNs populations across the continuum of care including state health public hospital funding and Commonwealth public subsidisation for private services and pharmaceuticals under the Medicare Benefits Schedule (MBS) and the Pharmaceutical Benefits Scheme (PBS);
- the productivity of the pool of these public resources to achieve allocatively efficient benchmarked health outcomes, approximated by variables of population health status; and
- population health needs expressed by populations' capacity to benefit from resourcing to achieve the benchmarked efficient outcomes.

In this regard the HORSt as the first step replaces the reliance on historical funding and activity to allocate funds from the state to LHNs. It also positions public funding between the state and LHNs as a residual needs adjusted public funding component of the continuum of care which promotes equity and allocative efficiency.

The scope of this research only addresses step one. It does not address issues relating to the ABF model that informs the second step. Nonetheless the compatibility between the HORSt and ABF is examined and verified in the literature review in Chapter Two. ABF is left unchanged in its role as the second step. The funding shares from the first step can be expressed in either dollars or ABF volume. Furthermore, the HORSt acting as the starting point in a broader funding model does not seek to incorporate supply side cost issues or adjust for patient flows between LHNs. Both aspects are however important and a discussion of these issues in union with ABF is provided in the concluding chapter. The HORSt also has the potential as a distribution tool for Commonwealth to the States with IHPA translating the HORSt quantum into NWAUs. This is also discussed in the conclusion.

Cognisant of the interactions of the continuum of care and social determinants that give rise to health outcomes, the HORSt uses measures of population health status that reflect burden of disease to proxy health outcomes at the population level. As such, the HORSt is not specifically designed to inform equity adjustments for specific health program areas, or for specific health interventions, treatments, or procedures.

1.1 SUMMARY OF INNOVATIONS AND UNIQUE CONTRIBUTIONS OF THIS THESIS

The HORSt is specifically designed to address health inequities by considering each LHN's populations' capacity to benefit from taxpayer funded health resources. Uniquely it does so by examining the social determinants of health that give rise to health inequities evident in health outcomes (approximated by a measure of population health status) and by considering the interaction of these social determinants with the allocative efficiency of the bulk of taxpayer resources provided to local populations across the continuum of care. This methodological approach is unique and thus the study makes an important contribution to knowledge.

The resources included across the continuum of care are Australian Government funding of the Medicare Benefits Schedule (MBS) and the Pharmaceutical Benefits Scheme (PBS) and NSW public state health resources (funded by the Australian Government and State Governments). At the time of the study, according to the Australian Institute of Health and Welfare (AIHW), these resources constituted $105.8 billion in 2016, representing 62% of total health expenditure in Australia and 92% of total governments tax payer funded health expenditure (Australian Institute of Health and Welfare 2017a, pp. 22-30).

The HORSt represents a departure from mainstream health reform and state health funding models in Australia that have largely focused on improving the technical efficiency of hospital outputs (Bennett 2012; Paterson 2002, p. 313). The HORSt places emphasis on the allocatively efficient and equitable achievement of improving health outcomes and does so by not violating any regulatory or constitutionally prescribed arrangements that exist under Australia's federation.

In terms of innovation, the development of the HORSt in this thesis makes a number of unique contributions. In summary, the HORSt as a state public health funding tool is the first of its kind to:

1. consider and enumerate the productivity of the bulk of taxpayer resources across the continuum of care;
2. recognize in a mixed private / public system, state health funding as component of an integrated health care system and not a standalone silo of publicly provided services;
3. measure and use the relative allocative efficiency of the main taxpayer provided and subsidised resources across the continuum of care to produce desirable health outcomes to represent a benchmark;

4. represent population health needs in the context of populations' capacity to benefit to achieve benchmarked health outcomes; and
5. enumerate what the state health system should distribute to local populations to achieve funding equity aligned to population needs and with respect to public subsidisation across the continuum of care.

The methodology employed in developing the HORSt also represents a unique contribution to the literature of population needs-based funding models in health care. The HORSt utilises Two-stage Data Envelopment Analysis (DEA), a linear programming econometric tool which assesses efficiency and then uses robust regression to assess variables that can best explain the efficiency (Fatimah & Mahmudah 2017, pp. 1,974).

Contextualised to the HORSt, the DEA will measure for 88 small populations across NSW the allocative efficiency of taxpayer resources across the continuum of care to achieve desirable levels of health outcomes. Populations that are found to be allocatively efficient determine the benchmark.

Having established the benchmark, the second stage uses predictive regression techniques to develop need indices for populations across NSW. The regression identifies social determinants of health that predict each population's ability / inability to achieve the benchmark. Need indices are informed by each population's predicted allocative efficiency to that of the benchmark population. Need indices are an expression of vertical equity and are then used to inform shares of funding resources between the State and the LHNs with respect to the pool of resources (MBS, PBS and state health). The State resource distribution to LHNs are a residual given that MBS and PBS resources are not distributable.

1.2 STRUCTURE OF THIS THESIS

This thesis is organised into seven chapters.

Chapter 1 - Introduction

Prior to outlining the specific aims and research questions for this study, the first chapter provides an overview of the rationale and background supporting the development of the HORSt. This chapter also provides a broad overview of the Australian health care system in terms of health outcomes, health inequalities and health inequities. An outline of the governance and funding distributions of public health funded and taxpayer subsidised health funding in Australia is provided.

The chapter concludes by outlining the study's scope and contextual information about the NSW health system, used as a case study, relevant to the time of the study.

Chapter 2 - Literature review

The second chapter provides a review of the literature relevant to the development of the HORSt. Specifically, the concepts of equity and efficiency contextualised to theories of social justice and public health funding models and the Australian health care system are examined. The effectiveness of public health funding models used in Australian states and their ability to promote equity and efficiency are reviewed and contextualised to the literature. International approaches to regionalised resource allocation models are critiqued along with methodological approaches employed to represent population health needs and health outcomes. Alternative resource distribution methodologies and measures of need from the education sector are also considered. The gaps and limitations of previous research are highlighted and examined in the context of opportunities for this study and summarised. The chapter concludes by outlining the conceptual framework derived from the literature that supports the methodological design of the HORSt and the study's research questions.

Chapter 3 – Governance and funding arrangements review

Chapter Three is a review of the governance and funding arrangements of the Australian Health Care system that were briefly introduced in Chapter One. This chapter is important for the HORSt as it examines the extent to which equity and efficiency are promoted within each layer of publicly provided and subsidised health care in the Australian health care system. Relevant legislative issues that bound the Australian federal system of government are outlined.

Drawing upon the conceptual framework established via the literature review, each layer of funding is assessed for theoretical and practical inclusion in the development of the HORSt methodology so as to recognize the productivity contributions of resourcing across the continuum of care to the achievement of health outcomes. In doing so, this chapter demonstrates that state health resource distribution not only has a role to provide public health services but can act as residual funding enabler to correct for inequities and allocative inefficiency that is exacerbated by Commonwealth provided public subsidisation and constitutionally protected private practice.

Chapter 4 - Methodology

Chapter Four outlines the methods applied in the development of the HORSt. This chapter commences with detailing the ethics approval undertaken for the thesis. Guided by the conceptual framework developed from gaps and limitations revealed in the literature review and issues surrounding the governance and funding arrangements, the methodology is justified and outlined in alignment with the thesis aims and research questions.

The nature of the research construct and quantitative approach is then justified along with the specific econometric methodology used in this thesis being Two-Stage DEA. This involves:

1. DEA for establishing benchmarked allocative efficient health outcomes; and
2. Robust regression as a predictive methodology for identifying social determinants / health needs that give rise to the allocative efficiency of health outcomes.

The Two Stage DEA methodology employed represents the first two stages in the development of the HORSt. A third stage is outlined for the HORSt being the process of developing from the DEA and regression results, health need indices for each of the 88 populations defined by the Australian Bureau of Statistics (ABS) data structures of the 15 NSW LHNs. The process for calculating LHN shares of resources and informing resource distribution to meet local health needs is then prescribed.

Chapter 5 – Data sources

Chapter Five outlines and justifies the data sources to be used with the methodology. This chapter first describes and justifies the ABS 88 small area populations within the 15 NSW LHNs to be used in the analysis subject to data availability. Variables to be included in the DEA are then presented and validated. Finally, variables for assessment in the regression are examined and outlined. This chapter also includes quality assurance processes undertaken for data extractions and provides descriptive data analysis of key variables to be included.

Chapter 6 - Results

The sixth chapter presents the results for each of the 88 NSW populations from the analysis. First the results of the DEA are validated as meaningful representations of the benchmarked allocative efficient health outcomes. The regression analysis results are then presented and are shown to demonstrate realistic predictors of the DEA results. The derived health needs indices are then confirmed as understandable and logical indicators commensurate with relative health needs of the NSW population's and LHN's. The results for each NSW LHNs health needs share of funding is then calculated. These show the funding adjustments required from the state with respect to the pool of resources included in this study across the continuum of care to enable equity improvements. A comparison to current share of funding provided to LHNs for admitted and non-admitted activity in NSW is presented and examined.

Chapter 7 - Conclusions

The final chapter revisits the research questions of the thesis. Each of the aims and research questions are answered. The unique and significant contributions achieved in the research is outlined. Strengths and limitations of the research are highlighted. A discussion of the practical application for the HORSt is provided.

1.3 RATIONALE / BACKGROUND

The justification for developing a HORSt for Australian States is four-fold with evidence demonstrating that:

1. Health inequities, much of which are socially determined, exist in Australia and can be addressed;
2. The distribution of publicly funded and publicly subsidised health care in Australia is inequitable and can be improved;
3. State health funding models, irrespective of ABF, still use elements of historical funding that does not advance equity or efficiency; and
4. Previous resource distribution models seeking to address need emphasised horizontal equity (equality in funding access expressed by health system use) rather than vertical equity and health needs expressed in terms of capacity to benefit.

These issues are now introduced. A fuller examination of these issues in the development of the conceptual framework that underpins this research methodology is provided in the literature review in Chapter Two and in the review of governance and funding arrangements in Chapter Three.

1.3.1 Health inequities in Australia

In Australia significant health inequities exist for: people of lower socioeconomic status; the Indigenous population; people living with disabilities; rural and remote communities; and migrants with low levels of English. Inequities take the form of preventable illnesses and premature deaths

(Australian Institute of Health and Welfare 2016b, pp. 29-32; Turrell et al. 2006). The World Health Organisation (WHO) defines health inequities as:

> *"__avoidable__ inequalities in health between groups of people within countries and between countries. These inequities arise from inequalities within and between societies. Social and economic conditions and their effects on people's lives determine their risk of illness and the actions taken to prevent them becoming ill or treat illness when it occurs"* (Commission on Social Determinants of Health 2008a, emphasis not added).

The socially produced factors underpinning health status that give rise to health inequities are significant. A large body of international literature considers that the social and economic conditions in which people are born, live and work are the single most important determinants of health status (Aberg Yngwe et al. 2003; Case et al. 2008; Case et al. 2007; Chan 2008; Choi et al. 2015; Commission on Social Determinants of Health 2008b; Khanam et al. 2009; Satcher 2010; Theodossiou & Zangelidis 2009).

Sir Michael Marmot (2016) maintains that often in Australia there is a tendency to see health inequities as confined to the appallingly poor health of Indigenous Australians, whilst the reality is that people in the middle of the social hierarchy will have fewer years of healthy life than those at the top and those at the bottom have worse health than those in the middle. Moreover, for many people who are socioeconomically disadvantaged, multiple combinations of the attributes that are associated with health inequities often apply (Australian Institute of Health and Welfare 2016a; Health Policy Analysis 2014b). Problematically and somewhat compounding this issue in Australia is that a recent study of intergenerational mobility found that Australians have a restricted ability to improve upon the socioeconomic status of their family and that in an international context, Australia has a relatively low rate of socioeconomic mobility (Mendolia & Siminski 2015). Given this, there is a risk that health inequities can become entrenched within lower socioeconomic segments of the Australian community.

The study will explicitly target the improvement of health inequities, by considering the influence of measurable social determinants of health upon proxies of population health status. Variables representing population health status are examined and justified for inclusion in the HORSt in the literature review.

1.3.2 Inequitable distribution of and access to publicly funded and publicly subsidised health care in Australia.

Outside of public hospitals, the availability, distribution and financial accessibility of medical services are dominated by private doctors free to set their own fees (Johar et al. 2016). These fees are part taxpayer funded by Medicare rebates, with patients liable for any co-payments of fees that exceed the rebates (Department of Health and Ageing 2009, p. 7). Private doctors' rights of private practice are guaranteed by the Australian Constitution (Australian Senate 1946; Faunce 2009; Scully 2009).

In Australia, the financial and geographical access to health services can create health inequities (Duckett & Griffiths 2016a, p. 4; Turrell et al. 2006) and there is well established evidence that access to these services is more abundant in more affluent areas where doctors choose to live and work (Bickerdyke et al. 2002, p. 85; Eckermann & Sheridan 2016; McRae & Butler 2014, p. 281). There is also evidence of people forgoing treatment due to unaffordability of out-of-pocket costs (Australian Institute of Health and Welfare 2018c, 2018e; Duckett et al. 2014; Scott 2016; Sweet 2012). A fairer distribution of taxpayer funded resources that seeks to consider the social determinants of health that give rise to inequities, is warranted, along with improving the financial access. Reducing health inequities improves well-being and opportunity, promotes social cohesion and inclusion, increases workforce participation and productivity, helps to overcome other forms of disadvantage and reduces health system costs (Brown et al. 2012; Duckett & Griffiths 2016a, p. 4).

In developing the HORSt, the study will consider the total taxpayer funded resources spent on per capita basis on people in each LHN across the continuum of care. Adjustments to the state health budget allocation to each LHN will be guided by meeting the resourcing requirements to address health care needs in order to maximise equity of health funding across the continuum of care.

1.3.3 State health funding models reliance upon elements of historical funding

Due to the large size of the physical geography of Australia, most states, commencing with NSW in 1973, regionalised their public health care services to best provide care close to different regional populations (Eagar et al. 2001, p. 29; Palmer & Short 2014, p. 96). Regionalisation is an important principle of empowering local populations for decision-making regarding their own health care. The National Health Reform Agreement (NHRA) of 2011 made it mandatory for all Australian states to have LHNs by 1 July 2011 (Council of Australian Governments 2011, p. 5; Palmer & Short 2014, p. 97). Regionalisation of state health services requires states to utilise funding models to provide resources to LHNs. This distribution, between state government and LHNs, is the focus of this thesis.

The basis of service level agreements between the state and LHNs is largely historically determined by previous years' activity. Once this funding envelope is determined, ABF is used to purchase services from facilities within LHNs (Department of Health and Human Services Victoria 2014; NSW ABF Taskforce 2013b; Queensland Health 2014; SA Department of Health and Ageing 2014; System Purchasing and Performance 2013; Western Australia Department of Health 2014). Historical funding is regressive, stymies innovation and does not advance improvements in health outcomes (Broadhead 1991; Eagar et al. 2001; Hindle 2002).

Output-basedfinding models, such as ABF, promote technical efficiency, but create incentives to overproduce in that they fund utilisation and not need (Broadhead 1991; Eagar et al. 2001, p. 78). As such they cannot be used to establish appropriate resource distribution. The use of historical determinants to do so makes this evident.

The HORSt seeks to inform per capita resourcing on a health needs basis of geographical populations. Aggregated at the LHN level, this can inform resource distribution to meet population needs, ending the reliance on historical funding.

1.3.4 Previous resource distribution models - equality in funding access

Barr et al. (2014), Carr-Hill (1994), Carr-Hill and Sheldon (1992), Mooney (2009), Mooney et al. (1991) and Sheldon et al. (1993) find that the definition of health needs used in population needs-based resource allocation models has been all too often described in terms of health care utilisation and equity is achieved via providing equal access for equal need. These authors all concluded that these models have not sufficiently considered different populations' capacity to benefit from different resources and underrepresents unmet need by those who do not / cannot access the health system. Contrastingly, population health needs within the HORSt will be informed by vertical equity financial loadings, which reflect different geographical populations' capacity to benefit from resources subject to how the social determinants of health for these populations affect comparative rates of health outcomes.

1.4 AIMS OF THE STUDY

Specifically, there are three broad aims of the study that contribute to the development of the HORSt:

1. Develop the HORSt as a parsimonious, measurable and consistent benchmark of desirable health outcomes for states' LHNs' populations, relative to funding inputs across the continuum of care, so as to promote allocative efficiency and equity across populations.
2. Identify and incorporate measures of local geographical population health needs that can be used in resource allocation decisions.
3. Identify the share and quantum of taxpayer resources provided by the state to geographical populations to maximise equity of health funding across the continuum of care, in order to act as an enabler to improve equity of health outcomes.

1.5 RESEARCH QUESTIONS

The research questions for this study are best organised under its aims.

AIM 1: Develop the HORSt as a parsimonious, measurable and consistent benchmark of desirable health outcomes for states' LHNs' populations, relative to funding inputs across the continuum of care, so as to promote allocative efficiency and equity across populations.

RESEARCH QUESTIONS:

1. What measures / data of health status can best represent an acceptable level of desirable health outcomes for populations that can inform a benchmark?
2. What health service funding inputs should be included to represent the continuum of care?
3. What methodology should be applied to derive the benchmark?

AIM 2: Identify and incorporate measures of local geographical population health needs that can be used in resource allocation decisions.

RESEARCH QUESTION:

4. What are appropriate measures of population need that could be applied to support the HORSt?

AIM 3: Identify the share and quantum of taxpayer resources provided by the state to geographical populations to maximise equity of health funding across the continuum of care so as to act as an enabler to improve equity of health outcomes.

RESEARCH QUESTIONS:

5. What share of funding is required for each geographical population to adjust for population health needs so as to maximise equity of health funding across the continuum of care?
6. What quantum of funding is required to be adjusted by the state from the existing pool of resources used by each geographical population?

1.6 OVERVIEW OF THE AUSTRALIAN HEALTH CARE SYSTEM

This section provides background to the Australian Health Care System, outlining an overview of the funding and governance arrangements of the governments, providers and consumers. Health outcomes and health inequality in the Australian health care system are also discussed and contextualised to the rationale presented supporting the development of the HORSt. A comprehensive critique of the specific funding and governance arrangements pertinent to the advancement of equity and efficiency and legislative issues that can affect the development of the HORSt is provided in Chapter Three.

1.6.1 Overview of Funding and Governance arrangements

The provision of health services in Australia is a mix of public and private arrangements (Eagar et al. 2001, p. 26; Lairson et al. 1995, p. 475). Medical practitioners, excluding salaried staff in state-run public hospitals and community public health services, are entrepreneurial private operators and are free to set their own charges (Gadiel 2015, p. 1) and their rights of private practice and location of practice are constitutionally protected (Australian Senate 1946; Faunce 2009). Private services outside of state-run public hospitals and community-based services can attract out-of-pocket expenses to be paid by the user (Department of Human Services 2015).

The complexity of health funding and provider arrangements in Australia is summarised in Figure 1 (page 16). The origins of the complexity of funding and the mixed public private health care system arise from the federated system of government established by the Australian Constitution in 1901 and successive political reforms spanning from 1938 to the present day (Boxall & Gillespie 2013, pp. ix - x).

The contemporary roles of the Commonwealth and states as a funder or provider of health care can be summarised as follows:

- Commonwealth funding partially supports each state's public system; subsidises drugs via the Pharmaceutical Benefits Scheme (PBS) and subsidises the private sector via; Medicare Benefits Schedule (MBS) payments to medical practitioners; and via the Private Health Insurance (PHI) rebate.
- States provide funding and administration to public hospitals and community health services.

  (Palmer & Short 2014, pp. 81-2)

Moreover, the Commonwealth and states share funding arrangements for the National Disability Insurance Scheme (NDIS) (National Disability Insurance Agency 2017). Contributions are expected to be almost equal shares (Norman 2017).

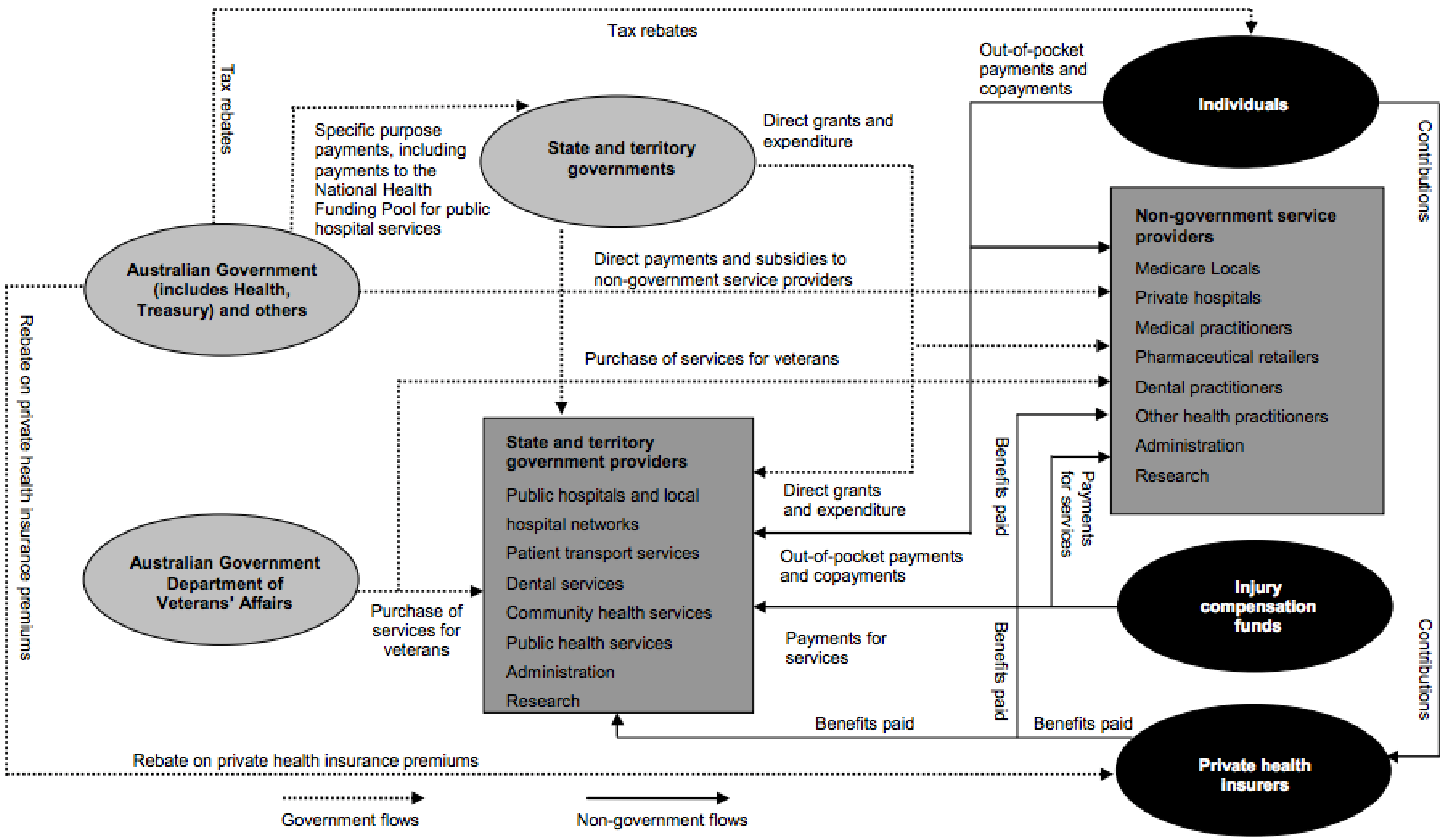
Universal public access via Medicare ensures that access to public hospitals is provided at no cost to public patients for Australian citizens and eligible residents. Medicare provides universal insurance for full or partial reimbursement of medical practitioners' fees, subject to:

- the Medicare reimbursement schedule;
- the type of practitioner; and
- the modality of the service; and safety nets.

The subsidisation of pharmaceutical costs through the PBS is provided for Medicare eligible patients (Department of Human Services 2015).

Figure 1 Structure of the Australian Health Care system and its flow of funds

From *Health Expenditure Australia 2015-16 (Australian Institute of Health and Welfare 2017a, p. 3)*



Private Health Insurance (PHI) is available for purchase to assist with the reimbursement of out-of-pocket expenses in private hospitals and for other medical services not covered by Medicare. Premiums are subsidised by the Commonwealth government via a rebate according to individual incomes (Palmer & Short 2014, pp. 11-2).

Commonwealth and state governments contribute taxpayer funds to public state health care services, predominantly public hospitals, with minor payments made by private health insurers and other revenue sources (Palmer & Short 2014, pp. 12-3). The largest component of Australia's health expenditure is state-run public hospitals, which represents approximately one third of the total Australian health expenditure(Australian Institute of Health and Welfare 2016c, p. 41). Of this expenditure, state governments contribute the majority of funding (54% in 2013-14), with the Commonwealth the next largest source of funding (37% in 2013-14) (Australian Institute of Health and Welfare 2016a, p. 38).

The nature of the health care system being either publicly funded by the taxpayer or taxpayer subsidised gives rise to questions of how funding is distributed for health care and whether or not this distribution is equitable amongst the population, so as to promote improvements in health outcomes. The distribution of taxpayer funded, or taxpayer subsidised services happen at multiple layers in the health system. For example: from Commonwealth to the states; from Commonwealth to private doctors; from Commonwealth to private health insurance holders; from Commonwealth to private individuals; and from states to regionalised areas (LHNs). Determining an equitable distribution between state government and LHNs, with respect to the allocative efficiency of the main sources of government funding across the whole continuum of care to produce health outcomes is the focus of this thesis.

1.6.2 Health outcomes, health inequality and health inequities in Australia

The Australian health care system is one of the most effective health care systems in the world. Life expectancy in Australia is higher than the Organization for Economic Cooperation and Development (OECD) average. Figure 2 on page 18 shows that the life expectancy at birth for children born in Australia in 2016 was the equal sixth highest amongst OECD nations, 82.5 years, equal to that of Israel and Norway, behind Luxembourg 82.8 years, Italy 83.3 years, Spain 83.4 years, Switzerland 83.7 years and Japan 84.1 years (OECD 2019).

Figure 2 Life expectancy at birth 2016

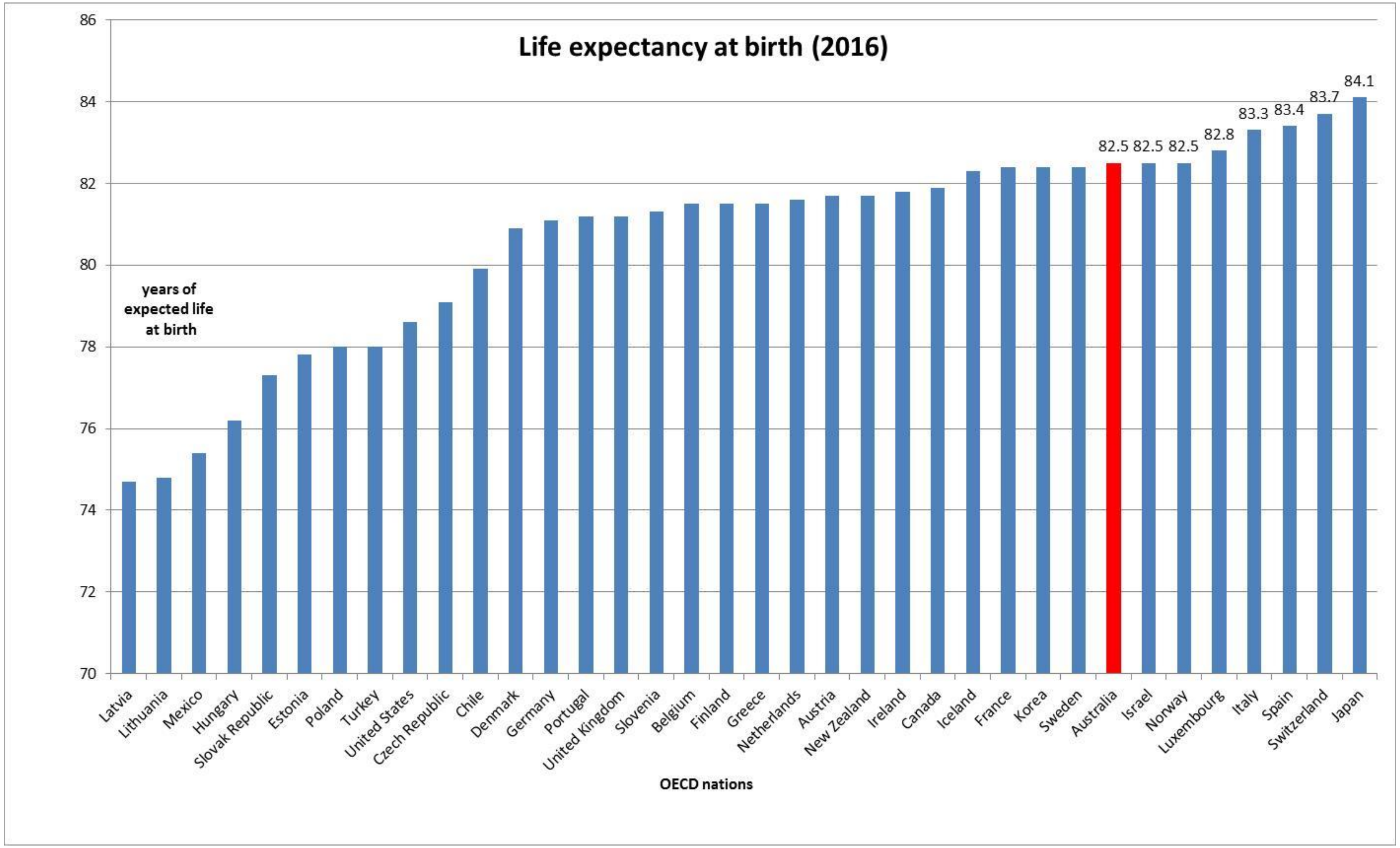


Figure 2 was constructed using data generated from the OECD online database *OECD Health Statistics: Health status* – life expectancy at birth indicator (OECD 2019).

Figure 3   Life expectancy in years and health spending per capita 2016

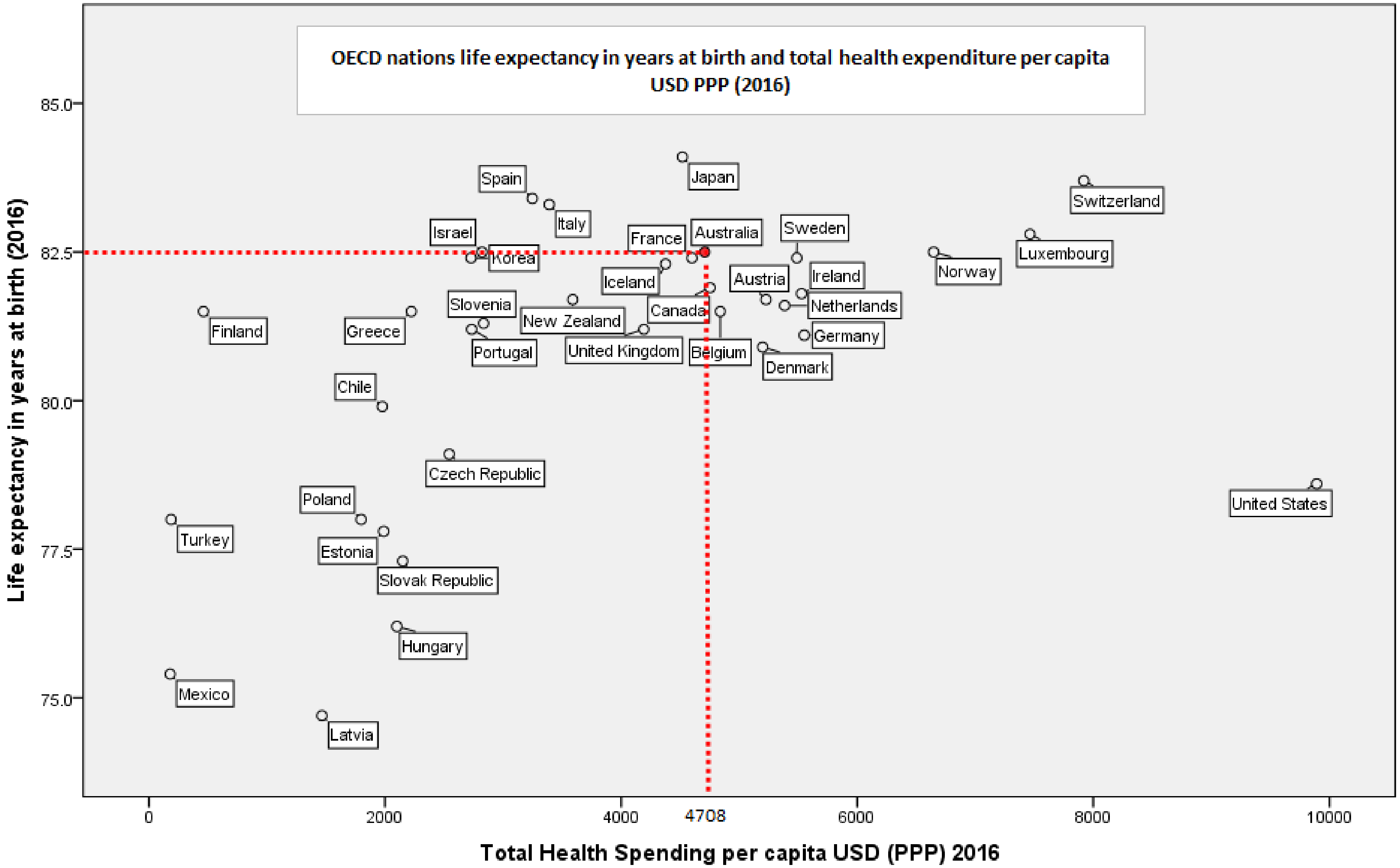


Figure 3 was constructed utilising the data from *OECD Health Statistics: Health status* – life expectancy at birth indicator (OECD 2019) and published OECD statistics pertaining to health expenditure in the publication Health at a Glance 2017 (OECD 2017a, p. 30).

In addition to superior life expectancy of Australians, the Australian health care system is also one of the most efficient systems in the world. Figure 3 on page 20 shows that in 2016 using USD purchasing power parity (PPP) the cost per capita of health spending in Australia, correlated to life expectancy, is substantially lower than many other OECD nations that have higher costs and / or lower life expectancy (OECD 2017a, 2019).

Whilst OECD statistics show that the average Australian enjoys comparative health outcomes that are the envy of many other nations, gains in health outcomes are not shared equally amongst the population. In Australia significant health inequities exist for people of lower socioeconomic status; the Indigenous population; people living with disabilities; rural and remote communities; and migrants with low levels of English (Allan et al. 2007; Australian Institute of Health and Welfare 2016a; NSW Department of Health 2004; Palmer & Short 2014; Turrell et al. 2006).

Australia's biennial report card "Australia's Health 2016" (Australian Institute of Health and Welfare 2016a, p. 518) highlights the following contemporary examples of health inequalities in Australia. As per Marmot's argument discussed (p9), these are not confined to the Indigenous population and most of these are in fact health inequities, meeting all definitional criteria of being socially produced, systematic in their unequal distribution across the population, avoidable and unfair. Examples from the report card include:

- "20% of Australians living in the lowest socioeconomic areas in 2014–15 were 1.6 times as likely as the highest 20% to have at least two chronic health conditions;
- Australians living in the lowest socioeconomic areas lived about 3 years less than those living in the highest areas in 2009–2011;
- If all Australians had the same death rates as people living in the highest socioeconomic areas in 2009–2011, overall mortality rates would have reduced by 13%—and there would have been 54,000 fewer deaths;
- People in low economic resource households spend proportionally less on medical and health care than other households (3.0% and 5.1% of weekly equalised expenditure, respectively, in 2009–10); and

- People living in the lowest socioeconomic areas in 2014–15 were more than twice as likely to delay seeing—or not see—a dental professional due to cost compared with those living in the highest socioeconomic areas (28% compared with 12%)"

(Australian Institute of Health and Welfare 2016a, p. 130).

Ambulatory Care Sensitive Conditions (ACSCs) also known as conditions that are Potential Preventable Hospitalisations (PPHs) are further markers of health inequality. PPHs[5] are conditions that are deemed to be treatable in an ambulatory care setting. When evident in hospital inpatient data, the literature has long considered them as a proxy of potentially preventable illness and avoidable hospitalisations (Ansari et al. 2006; Falster et al. 2016; Longman et al. 2011; Longman et al. 2015; Victorian Health Information Surveillance System 2016). However, more contemporary Australian evidence has concluded that PPHs represent sicker patients (Falster et al. 2015; Falster et al. 2016).

Whilst the social causes of poor health evident in Australia are beyond the remit of the health system alone, the challenge of addressing health inequities can be nonetheless influenced by the distribution of taxpayer provided and taxpayer subsidised health funding to enable improvements in health outcomes. This study seeks to improve resource distribution to alleviate inequities and enable better health outcomes.

1.6.3 Time Frame for the case study

Population needs-based resource distribution tools typically use secondary data sources, such as census data, to develop need indices that inform resource distribution. These are designed to be stable enough to use for multiple years resource distribution and updates to need indices typically occur when new census / population data becomes available (Inter-Government & Funding Strategies 2005b; Rice & Smith 2001). The HORSt need indices that this research will develop using similar secondary data sources are also designed to be stable enough to inform multiple individual years resource distribution. For the purposes of the developing this research, in addition to using the latest census data, the HORSt uses three years of hospital and expenditure data to 2015/16 and measures of central tendency justified in Chapter Five to demonstrate a proof of concept model for 2015/16. Some geographical data structures used are from earlier years using official Government sources. However, these are still relevant and do not affect the outcomes of the model. Chapter

[5] For the remained of this thesis the term PPH will be used.

Five outlines and justifies all the data used in the model. As a proof of concept, the HORSt can be applied to later years' data. A discussion of operationalising the HORSt to do so is included in the discussion in the final chapter.

1.6.4 Regionalised health structures in Australian states at the time of the study

The organisation of regionalised services within states is a significant factor for this study. Aspects of physical and human geography in the context of resource distribution and the advancement of equity and efficiency require consideration. A contemporary summary of the structure of regionalised services within states in 2016 is summarised in Table 1.

Table 1 exemplifies the diversity amongst states in regionalising health services. To put this regionalisation into context, the human and physical geography size of each state is summarised in Table 2.

Table 1 Regional organisation of health services in Australia in 2016

State	**Networks / Districts / Services**
NSW	15 LHNs + 3 Speciality Networks + I Contracted Service Division
Victoria	88 LHNs (Local Hospital Networks)
Queensland	19 Hospitals and Health Services
Tasmania	1 THS (Tasmanian Health Service) -2016 previously had Tasmanian Health Organisations (THOs)
South Australia	5 LHNs (Local Health Networks
Western Australia	5 Health Services + 1 Notional Local Health Network + 1 Speciality service
Northern Territory	2 Health Services (Top End Health Service + Central Australia Health Service)
Australian Capital Territory	1 Australian Capital Territory (ACT) Local Hospital Network Directorate

Table 1 sources: (Administrator National Health Funding Pool 2016b; Department of Health and Human Services Tasmania 2015)

Table 2 Human and physical geography of states

State	Area square kms	% Australian land mass	Population '000' estimate 2016 June	% of Australian population
NSW	800,642	10.41%	7,725.9	32.0%
Victoria (VIC)	227,416	2.96%	6068.0	25.2%
Queensland (QLD)	1,730,648	22.50%	4,844.5	20.1%
Tasmania (TAS)	68,401	0.89%	519.1	2.2%
South Australia (SA)	983,482	12.79%	1,708.2	7.1%
Western Australia (WA)	2,529,875	32.89%	2,617.2	10.8%
Northern Territory (NT)	1,349,129	17.54%	244.9	1.0%
Australian Capital Territory	2,431	0.03%	396.1	1.6%

Table 2 sources: (Australian Bureau of Statistics 2016a; Geoscience Australia 2017).

Comparing the data from both tables shows that ACT with the smallest physical geography and population has just one service, the NT the third largest in physical size with the second smallest population, spread the most sparsely, has two. NSW has a third of the Australian population and 10% of the land mass and 15 LHNs, whilst Western Australia has 11% of the population and a third of the land and 5 Health Services. Seemingly an anomaly compared to other states regionalised health structures, Victoria with just 3% of the land mass is the most regionalised and decentralised with 88 local hospital networks. Hospital networks are an apt description for Victorian regionalisation where each 'network' is effectively just a hospital and community health services are separately managed (Administrator National Health Funding Pool 2016b).

Given the literature demonstrating the differing effects of social determinants on health outcomes, it is logical to consider that differences in urbanisation, rurality, population size and socioeconomic composition and regionalised health structures between states, will likely result in a tool like the HORSt having different levels of relevance for regional resource distribution to improve health inequalities and inequities. The HORSt is logically going to be more applicable in states and territories that face more dispersed and socioeconomically different populations, where inequalities and inequities are more apparent and where the supply of services are scarcer.

NSW has a large remote geographical area, one third of the Australian population and also has one third of the Australian Indigenous population (Australian Institute of Health and Welfare 2014a). By contrast, Victoria has a mix of well-populated metropolitan and regional areas, little land classified as remote, no land classified as very remote and whilst having 25% of the Australian population, it has only 3% of the Australian Indigenous population (Australian Institute of Health and Welfare 2014a).

Figure 4 illustrates remoteness in Australia. NSW, Queensland, the Northern Territory, Western Australia and South Australia have areas of remoteness that are not evident in Victoria or Tasmania.

Figure 4 Remoteness map of Australia

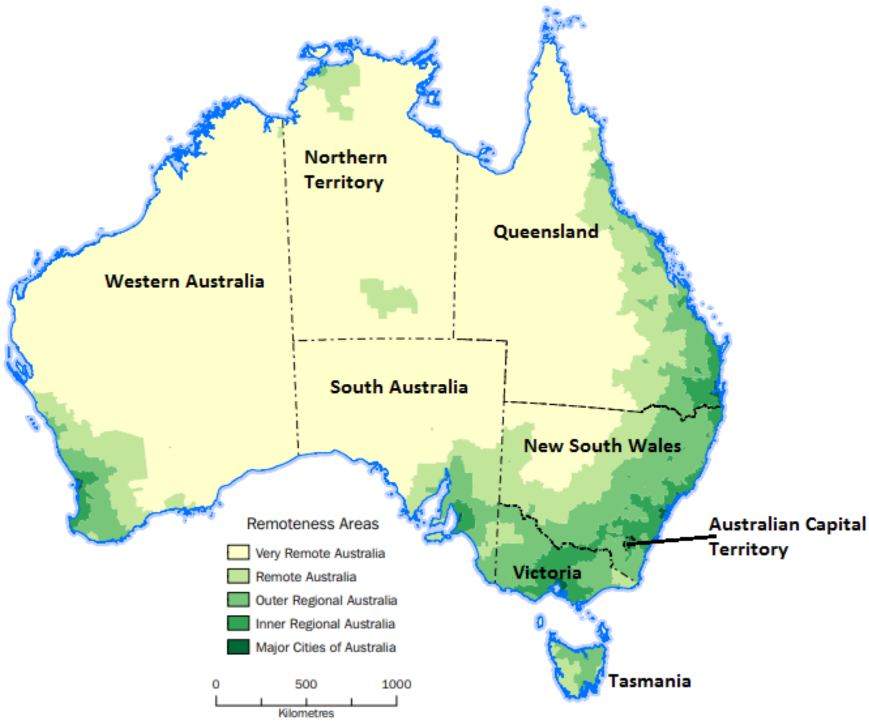


Figure 4 is adapted from the 2011 Australian Statistical Geography Standard: Remoteness Structure Map *(Australian Bureau of Statistics 2011, p. 2).*

1.6.5 The NSW public health system at the time of the study

According to the 2015-16 NSW Health annual report, the NSW Health is the largest health care system in Australia and one of the largest in the world with 111,000 staff servicing 7.7 million people and administering a $20.7bn budget. The overarching key directions for the NSW public health system at the time of the study were:

• keeping people healthy and out of hospital;

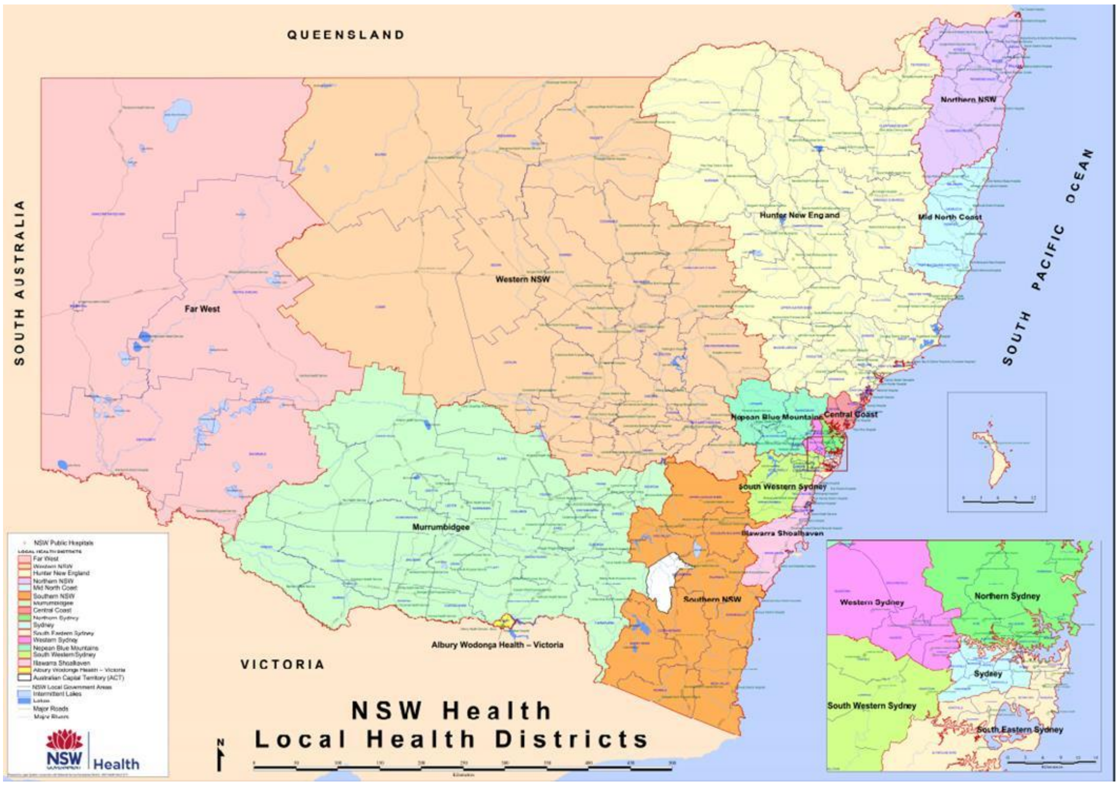
• providing world-class clinical care; and

• delivering truly integrated care

(NSW Ministry of Health 2016, p. 2).

As discussed, the regionalised structure of NSW Health involves 15 LHNS which are depicted in the map in Figure 5.

Figure 5 NSW LHNs at the time of the case study 2016



Source: (Epidemiology and Evidence 2015).

The NSW funding model for each region is expressed through individual service level agreements between the NSW Ministry of Health and each LHN. The majority of each LHN's operating revenue, (budget), is expressed in National Weighted Activity Units (NWAUs) which are multiplied by a state price per NWAU to determine the activity budget for Acute, Emergency Department, Sub Acute and Non-Acute Services, Acute Mental Health and Non admitted services. The determination of each LHNs activity is by default the primary instrument of resource distribution between the NSW State Government and regional areas (NSW ABF Taskforce 2013b; NSW Ministry of Health 2017).

The annual volume of services for each LHN (called an activity target) is largely determined on historical factors of the previous year's activity and population growth subject to adjustors. The

official NSW Ministry of Health statements to the Administrator of the National Health Funding Pool of how targets are to be formed confirm this, i.e. in the context of setting targets NSW reports:
"Provisional estimates and historical activity measures provide the basis for discussions with individual LHNs and subsequent negotiations for approval or adjustment" (Administrator National Health Funding Pool 2016a).

However, further statements provide a perspective that population health needs are more widely considered than history i.e.:
"*Ensuring access to health services for local populations is a key objective of NSW health policy. The Health Services Act 1997 stipulates that in determining LHN budgets, the Minister have regard to the size and health needs of the local population and provision of services to residents outside the local area. Accordingly, targets are adjusted considering factors appropriate to each LHN and service type, rather than simple extrapolation from historical activity data. The factors considered are reviewed on an annual basis"* (Administrator National Health Funding Pool 2016a).

The emphasis of the latter statement regarding the importance of population health needs in setting LHN activity targets in NSW requires examination. When the factors used for establishing NSW LHN activity target setting and their contributions to setting the target were assessed by the MoH, equity plays a minor role and is offset against performance negative adjustors. In 2015/16 adjustors and their contributions to LHN activity targets were as follows:

- Weighted population change -population growth component (44%);
- Activity trend -historical activity (28%);
- Readmission within 28 days -performance adjustment (5%);
- Potentially Preventable Hospitalisations -performance adjustment (5%);
- Expected Health Utilisation Index (EHUI / HNI) Health needs / equity adjustment only applied as a positive adjustor should the current relative utilisation (RU) rate is less than the HNI which itself is a utilisation index (16%);
- LHN Specific adjustments (2%).

(Foley 2012; NSW Ministry of Health 2017; Slater 2014).

Higher rates of readmissions within 28 days of discharge; higher rates of Potentially Preventable Hospitalisations (PPHs); and higher rates of current relative utilisation that exceed the health needs index, are all negative adjustors in determining the target (NSW Ministry of Health 2017). However, given the abundant literature on these adjustors being strongly influenced by social determinants

(Kangovi & Grande 2011; Kansagara et al. 2011; Kirby, S et al. 2010; Kirby, SE et al. 2010; Mele et al. 2018) and therefore beyond the control of health care facilities and LHNs, the use of these elements as a punitive measure is questionable. In fact, it is logical considering the weight of this evidence and the linking of social determinants with health outcomes that doing so exacerbates inequity.

Table 3 on page 28 demonstrates at the time of the case study, NSW Health reported that the volume and cost of activity for LHN populations across inpatient and non-admitted programs to be valued at $12.5 billion. The table shows the majority of this activity (91%) was funded under ABF, however some small-scale facilities within some LHNs, primarily rural ones, were funded by block grants and other sources. This table will be a component of the pool of resources to be redistributed to LHNs under the HORSt:

- after the productivity of these resources in conjunction with resources from the MBS and PBS are assessed for their contributions to allocative efficiency of achieving benchmarked health outcomes; and
- with respect to social determinants within the populations that influence the achievement of the benchmark.

Table 3 2015-16 total costs of NSW LHN populations' public admitted and non-admitted activity by LHN of residence

		Clinical Stream costs in $Millions								
LHN Of Usual Residence	**Funded by**	**Acute**	**Acute MH (Mental Health)**	**ED**	**NAP (Non-admitted)**	**Non Grouped to SNAP (Sub and Non Acute Patient)**	**Other**	**SNAP**	**Sub Acute MH**	**Total**
Central Coast	ABF	410	26	80	161	2	0	47	6	731
	Block	0	0	0	0	0	0	0	1	2
	Other	0	0	0	0	0	4	0	0	4
	Total	**411**	**26**	**81**	**161**	**2**	**4**	**47**	**6**	**737**
Far West	ABF	32	3	10	18	0	0	5	2	70
	Block	2	0	1	6	0	0	0	0	9
	Other	0	0	0	0	0	0	0	0	0
	Total	**33**	**3**	**11**	**23**	**1**	**0**	**5**	**2**	**79**
Hunter New England	ABF	869	63	185	232	0	5	58	7	1,419
	Block	57	1	32	32	9	0	0	3	134
	Other	0	0	0	157	0	3	0	0	160
	Total	**925**	**64**	**216**	**421**	**10**	**9**	**58**	**9**	**1,713**
Illawarra/ ShoalHaven	ABF	444	31	97	94	0	0	55	6	728
	Block	8	0	8	29	18	0	0	0	64
	Other	0	0	0	44	0	0	0	0	44
	Total	**452**	**32**	**105**	**166**	**19**	**0**	**55**	**6**	**836**
Mid North Coast	ABF	286	23	64	59	0	0	14	2	449
	Block	13	0	4	6	6	0	0	0	29
	Other	0	0	0	41	0	0	0	0	42
	Total	**299**	**24**	**68**	**106**	**6**	**0**	**14**	**3**	**519**
Murrumbidgee	ABF	199	11	43	8	0	0	20	6	288
	Block	53	1	36	7	12	0	0	0	109
	Other	0	0	0	13	0	6	0	0	19
	Total	**252**	**12**	**79**	**28**	**12**	**6**	**20**	**6**	**415**
Nepean Blue Mountains	ABF	327	26	68	130	1	0	29	1	581
	Block	0	1	0	16	0	0	0	1	18
	Other	0	0	0	0	0	0	0	0	1
	Total	**328**	**27**	**68**	**146**	**1**	**0**	**29**	**1**	**600**
Northern NSW	ABF	301	23	93	47	1	0	24	1	489
	Block	4	0	3	5	0	0	0	1	14
	Other	0	0	0	66	0	1	0	0	67
	Total	**305**	**23**	**96**	**119**	**1**	**1**	**24**	**2**	**570**
Northern Sydney	ABF	562	52	124	216	1	1	62	0	1,018
	Block	10	5	0	3	0	0	0	3	21
	Other	0	0	0	37	0	0	0	0	37
	Total	**572**	**57**	**124**	**256**	**1**	**1**	**62**	**3**	**1,076**
South Eastern Sydney	ABF	694	49	153	227	0	0	97	6	1,226
	Block	2	1	0	6	0	0	0	0	9
	Other	3	3	0	11	0	0	0	0	17
	Total	**698**	**53**	**153**	**244**	**0**	**1**	**97**	**6**	**1,252**
Southern NSW	ABF	159	14	46	25	1	0	21	2	269
	Block	11	1	7	2	4	0	0	6	30
	Other	0	0	0	32	0	1	0	0	32
	Total	**170**	**15**	**53**	**59**	**5**	**1**	**21**	**8**	**331**
South Western Sydney	ABF	902	56	168	261	2	0	82	1	1,473
	Block	0	1	0	8	0	0	0	0	10
	Other	0	0	0	57	0	0	0	0	57
	Total	**902**	**58**	**169**	**326**	**2**	**0**	**82**	**1**	**1,540**
Sydney	ABF	508	45	100	110	0	0	54	0	818
	Block	2	0	0	18	0	0	0	0	20
	Other	0	0	0	55	0	0	0	0	55
	Total	**509**	**45**	**101**	**184**	**0**	**0**	**54**	**1**	**894**
Western NSW	ABF	331	9	78	29	3	1	17	3	471
	Block	43	19	20	1	5	0	0	1	89
	Other	0	0	0	1	0	3	0	0	4
	Total	**374**	**28**	**97**	**31**	**8**	**4**	**17**	**4**	**564**
Western Sydney	ABF	774	40	152	295	1	0	65	6	1,334
	Block	0	21	0	12	0	0	0	1	35
	Other	1	2	0	1	0	3	0	0	7
	Total	**776**	**63**	**153**	**309**	**1**	**3**	**65**	**7**	**1,376**
NSW	ABF	6,796	472	1,462	1,912	13	10	651	49	11,363
	Block	205	52	112	152	56	0	0	16	595
	Other	4	5	0	516	0	21	0	0	546
	Total	**7,006**	**529**	**1,574**	**2,580**	**69**	**31**	**651**	**65**	**12,503**

Source: (NSW ABF Taskforce 2019).

1.7 PROJECT SCOPE

The development of the HORSt as an instrument of population needs to inform resource distribution between state and the LHN is designed to be a component of a broader funding model rather than all-encompassing funding model. Whilst the scope of this study is well defined within the stated aims and research questions (sections 1.4 and 1.5 pages 11 - 12), questions arise to the inclusivity of other factors or components that might logically be expected to be included in a population needs-based funding model to support its functioning. This section clarifies the scope of this thesis in anticipation of logical issues that may arise which are nonetheless beyond the remit of the HORSt research. Table 4 is a summary of these issues which are out of scope for this thesis. A discussion supporting the rationale for doing so follows.

Table 4 Summary of out scope issues for this thesis

Out of scope for thesis	Rationale
Informing shares of specific health programs	Further research is required beyond the proof of concept stage and very broad approach taken by the HORSt in terms of the measurement of health outcomes and how this could translate the HORSt methodology to inform specific program areas. Moreover, given the HORSt approach to including the productive capabilities of the continuum of care and given that health programs are components of that continuum, health program shares will not be informed by this research.
Cost and supply issues	Can be informed by ABF and other aspects of the payment model.
ABF / Purchasing services (outputs) between LHN and facilities	The HORSt complements and does not replace ABF. The HORSt does not seek to alter the operation of ABF as a payment currency used for purchasing decisions between LHN and facilities. ABF remains as key second step in the broader funding model after the HORSt has guided the resource distribution between the state and the LHNs.
Patient flows adjustment between LHNs and to Speciality network services	The HORSt is concerned with resource distribution between state and LHNs. Further research is required to develop policy for flows adjustment from LHNs to Specialty network services and between LHNs.
Capital planning	Further research is required for the applicability of the HORSt to assist with capital decision making.
Resourcing distribution beyond recurrent distribution of state health funding to LHNs.	The applicability of the HORSt methodology to other taxpayer funded / subsidised resource distribution issues that arise between governments and local areas are discussed in the concluding chapter.

As per the aims of this study the development of the HORSt as a tool, seeks ultimately to inform resource distribution of shares of state health funding to LHNs that are required to enable maximisation of equity in funding to achieve improvements in health outcomes commensurate with a benchmarked level of desirable health outcomes. Whilst the use of age-standardised PPHs, as a measure of population health status and proxy measure of health outcomes is critiqued and justified along with consideration of alternatives, the applicability of using this measure to individual program budget areas used by state health systems such as (Acute / Emergency / Non-admitted / Sub Acute / Mental Health / Teaching and Research etc), as per used in NSW (Inter-Government & Funding Strategies 2005b; NSW ABF Taskforce 2019) is not specifically assessed in this thesis. This is because the focus of this research is to demonstrate the HORSt methodology as a proof of concept model of a broad top-level tool of resource distribution between geographic communities. It does not seek to prescribe individual resource distribution for specific state health programs within those regions. Furthermore, there are conceptual differences of purpose between the HORSt, taking a health outcomes approach to health needs with respect to resourcing across the continuum of care and eliciting health needs of specific health programs which in themselves are components of the continuum of care.

As an equity enabler and resource distribution component within a funding model, the HORSt is not designed to address the costs of health system facilities or supply issues. These matters are important logical considerations within health funding models, nevertheless such factors are out of scope for this thesis. Decision making around how to pay for facilities and services can be informed by ABF and other aspects of the current payment model after the HORSt is applied to guide budget shares to LHNs. Moreover, the HORSt does not act as replacement to ABF as a payment model between LHNs and facilities. The HORSt can be demonstrated to complement ABF. Matters pertaining to the use of ABF as a payment currency for outputs are therefore out of scope for this study.

The HORSt considers population needs in terms of the LHN of residence of the patient. However, patient flows are an important determination for the funding model where patients living in one LHN can seek services from another or from a speciality network service and this situation is appropriate considering that it is not economically viable to have major tertiary and teaching hospitals for example in every LHN. The state pool of funds shown on page 28 to be included as the state funding component in the HORSt pool alongside other taxpayer subsidised resources from the

Commonwealth government, represent state expenditure by LHN of residence including flows to other LHNs and speciality network services. The HORSt as a broad tool of population needs-based funding considers each population's health needs regardless of the location of supply of services. However, in operationalising a funding model, where the HORSt is a component tool being the first step outlining the distribution of state resources to LHNs at a macro level, flows adjustment will be necessary as part of the next stage in the funding model. The methodology for flows adjustment is out of scope for the research agenda of this thesis.

The HORSt methodology developed in this thesis is primarily concerned with guiding resource distribution of the recurrent state government funding between states and local populations. Capital works developed for the state health system, via either public or private partnership capital funding enterprises are therefore out of scope for this study.

Notwithstanding these out of scope issues, the HORSt methodology can be considered for other resourcing decisions beyond that of recurrent health funding distribution between state and LHN. The applicability of the HORSt methodology with respect to other resource distribution decision making (including non-health applications) is discussed in the study's concluding chapter.

1.8 CHAPTER SUMMARY

This chapter has outlined the rationale for the study and provided an overview of the governance arrangements of the mixed private and public health system in Australia; the challenges faced in terms of health inequalities and inequities that are associated with poor socioeconomic determinants of health; and equity issues that arise from health system funding. Specifically aligned to the study aims, the distribution of taxpayer subsidised health care amongst the mixed private / public system in Australia is not equitable and the state public health systems face a continuing issue of how to distribute resources to regionalised populations. Background information pertaining to NSW, to be used as a case study has been provided, along with the study scope

The unique and significant contributions made by the HORSt and the study aims have been justified and outlined. The development of the HORSt shifts the focus at the state level from paying for outputs, to providing a funding enabler for outcomes and a new process for population needs-based assessment of resource distribution that considers the interactions of integrated care via the achievement of equity in funding for taxpayer subsidised resources across the continuum of care.

CHAPTER TWO – LITERATURE REVIEW

2.0 INTRODUCTION

As outlined in the previous chapter, the development of the HORSt seeks to recognise health inequities evident in geographical populations' health outcomes so as to guide more equitable resource distributions to regional populations within states' LHNs. This chapter provides a high-level overview of the literature in this area and critique of the concepts of equity, efficiency and health needs, contextualised to public health funding models used in Australia and with respect to the main theories of social justice. As NSW is to be used a case study for the HORSt and as NSW operated the longest running population needs-based funding model in Australia to address equity issues, the examination of this former funding model's ability to promote equity and efficiency is reviewed.

The methodology employed in this literature review purposely considered English language academic and policy literature surrounding Australian and international approaches to regionalised resource allocation models. The most common theories of social justice are also evaluated and contextualised to the concepts of equity and efficiency for the development of the HORSt. Alternative measures of approximating population health status, needs and health outcomes within resource distribution instruments were also reviewed.

School education in Australia faces similar challenges of public funding and similar governance arrangements under the Australian federated system of multiple public and private payers to that of state public health. As such, the methodological approach recommended by the Gonski review for school education funding to improve equity of enabling better educational outcomes is also considered for its translatability to state health funding for inclusion with the HORSt.

Each section of this literature review examines and critiques the gaps and limitations of previous research in the context of opportunities for this study. A summary box of these salient findings is presented at the conclusion of each section. The chapter concludes by synthesising each section's findings to outlining the conceptual framework that supports the study's research questions and the methodological design of the HORSt outlined in Chapter Four.

2.1 EQUITY IN HEALTH CARE

In health economics, equity issues frequently arise in the literature in the context of fairness regarding resource allocation decision making for health care (Macinko & Starfield 2002; Whitehead 1992). Fairness issues arise as health systems are concerned not only with improving the health outcomes of society, but with the fair distribution of resources (Mcguire et al. 1994, p. 55; Steinbach et al. 2016). Problematically, what constitutes fairness is a subjective moral decision and is guided by theories of social justice (Isuchiya & Dolan 2008; Singer & Mapa 1998). Elements of differing theories and perspectives of social justice are evident in most nations' healthcare systems and Australia in this regard contains a mix of different attributes of social justice (Marmot 2010). Four of the most common theories of social justice pertaining to the problem of health care resource allocation decision making, Libertarianism, Utilitarianism, Egalitarianism, and Rawlsianism (Steinbach et al. 2016) are examined in this section and contextualised to the Australian health care system for their ability to promote equity issues pertaining to fair resource allocation in the context of this study. These theories of social justice are then contextualised further to the study in a critique of the concepts of horizontal and vertical equity in the next section.

2.1.1 Social justice in health care

Libertarianism is based on the doctrine that individual's rights to freedom are paramount over that of the state and that the state should not infringe upon those rights (Rajczi 2016; Roberts & Reich 2002). Libertarians believe in minimal state involvement for the protection against negative rights by allowing state interference to ensure that the actions of one individual minimise the impacts for harm of the rights of another. Doing so positions the role of the state to safeguard individual freedoms and extend equity via equality for every member of society by guaranteeing legal protections (Andreescu 2015, p. 104).

In the context of resource allocation for health care, libertarian views extend to considering the distribution of health care resources by the state to guard against negative rights to freedom. Whether or not a person has a right to health and healthcare provided by the state to address that right however is an area of conjecture in the libertarian literature (Goodman 2005; Lenchus 2017). A less contentious example of where libertarian views would be in support of government provided care is vaccination programs, where negative rights of contagious preventable diseases may be guarded against (Roberts & Reich 2002, pp. 1056-7). The literature also describes libertarianism extending to paternalism by government regulations or programs to limit the negative harm from poor choices made by individuals that can affect their own health (Rajczi 2016, p. 97). However, libertarianism tends to seek to restrict the degrees of government involvement in paternalist actions, supporting individual freedoms; libertarianism has a strong view that individuals take responsibility for their own actions (Cappelen & Norheim 2005).

The importance of considering libertarian views of personal responsibility in health care is made clear by considering the concept of moral hazard. Moral hazard occurs whereby if medical insurance pays for health care, the financial consequence of illness are not bound upon the individual and there is therefore less incentive to the individual to maintain good health (Arrow 1963, p. 961; Christophe 2001; Ehrlich & G. 1972; Pauly 1968). Within universal publicly provided health systems and universal publicly provided health insurance schemes, there is policy and system design elements to encourage personal responsibility to address moral hazard. Examples are:

- in the United Kingdom (UK) clinical commissioning groups within the National Health Service (NHS) have recently adopted a policy of lifestyle rationing whereby it gives people who smoke or are obese a lower priority for publicly provided elective surgery, making them wait longer than those who do not smoke and are not obese (Pillutla et al. 2018; Shaw 2016);
- in the Australian health care system, it has been argued that the co-payments Australians face in accessing private medical practitioners, on top of Medicare's universal insurance reimbursement, acts as an instrument of encouraging personal responsibility (Barnes 2013; Rollins 2014). However, research indicates that there is little evidence to support this incentive argument. Co-payments are shown to reduce access to people whom are in need who then often end up in public emergency departments as ambulatory patients at great cost to the taxpayer (Eckermann 2014a, 2014b; Eckermann & Sheridan 2016).

Notwithstanding these examples of libertarian elements within public health systems and the need for health systems to minimise wasted resources associated with moral hazard, as Breyer and Kliemt (2015, p. 137) argue: *"libertarian views on rights tend to rule out coercive redistribution for purposes of public health care guarantees".* Contextualised to this study, libertarian views are therefore not specifically related to ethically supporting state health public resource distribution. Health funding at the population level cannot create incentives that impact on choices that individuals make, particularly in a mixed public private funding system like Australia. Moreover, libertarian views are also problematic to the study as state health systems in Australia are required by the Medicare principles, discussed in Chapter Three (page 94), to provide public hospital and community services free of charge on the basis of clinical need which does not consider individual actions that may give rise to that need (Council of Australian Governments 2011).

Utilitarianism is based on the principles of maximising benefits for the greatest number, where maximising benefits are measured by maximising society's utility / welfare (Mill 2001; Mulgan 2007). With regards to relative scarcity of health care resources, utilitarianism principles prescribe that resources should be allocated to those that have the greatest ability to benefit via considering the concept of opportunity cost (Stein 2015). Singer (1993, p. 25) uses an example to demonstrate this whereby an earthquake injures two individuals: one person has lost a leg and is in danger of losing a toe from her remaining leg; the other has a leg injury that can be saved but only if health care resources are not spent on saving the toe of the more injured person. Utilitarianism says in this situation you save the leg of the person with the saveable leg injury and forgo treating the person in danger of losing toe, as saving the leg yields more benefits. Doing so maximises benefits of scarce resources for society. Principles of utilitarianism are therefore often seen in the context of rationing for health care, particularly in the area of assessing societal benefits in health care evaluations (Nord et al. 1995a; Singer & Mapa 1998).

In terms of equity however, a key problem with utilitarianism is that in maximising societal benefits, individuals can be often viewed as means to others' ends (Roberts & Reich 2002, pp. 1,056). This is apparent in the case of Singer's earthquake example where the person forgoing treatment potentially losing a toe affords a means to the person whose leg might be saved by freeing up resources.

Egalitarianism is a form of social justice that treats all people equally and in terms of resources considers that people should get the same (Arneson 2013). Egalitarianism is often viewed as a competitive theory of social justice to utilitarianism. Stein (2015, p. 47) contends for example:

"If the slogan of utilitarianism is 'help those who can benefit the most', the slogan of egalitarianism is 'help those who are worse off'".

Considering this statement, egalitarianism can be demonstrated to be in direct contrast to utilitarianism by reconsidering Singer's earthquake victim's example above. Egalitarian principles would allocate resources to the more severely injured person with little or no benefit to that person and in doing so would create an opportunity cost of reducing the benefits available to the person who had a better chance with the resources to gain a benefit. This example highlights what Stein (2015) claims is a key weakness with egalitarianism that it is *"insensitive to relative benefits"* (p. 48). It can be concluded that egalitarian principles are therefore not concerned with the effectiveness of resource allocation.

Surveys of Australian's attitudes to resource allocation to those in need, consistently demonstrate that egalitarian values tend to trump utilitarian values, whereby people still will want resources directed towards those in perilous situations even where the expenditure of resources is likely to achieve little to any benefit (Nord et al. 1995a, 1995b). McKie and Richardson (2003) find:
"several empirical studies have also revealed that people are often prepared to sacrifice health gains in order to ensure that the more severely ill are given priority over the less severely ill" (pp. 2,409).

Jonsen (1986, p. 174) describes the rationale for these egalitarian attitudes within societies, although specifically contextualised to rescuing identifiable individuals facing avoidable death, as a *"rule of rescue"*. This is where society's rescuing actions that have little consideration to benefits are a moral imperative of a compulsion to act without considering rationality of the likely outcome and as McKie and Richardson (2003, pp. 2,407) state *"without too much thought to the opportunity cost of doing so"*.

In the context of equity and resource allocation, by its definition egalitarianism implies that equity is achieved via equality of opportunity to access. A worthy moral goal may well be that of equal health outcomes; however, egalitarianism is problematic for this study, as taking an equality approach does not consider that individuals are not equal in terms of their capacity to benefit from resources to achieve improvements in health outcomes.

In the context of the Australian health care system aspects of utilitarianism and egalitarianism can both be observed through resource allocation policy for the assessment of new technologies. Drugs and medical treatments are assessed for public subsidisation by considering how cost effective treatments are, often utilising measures such as Quality Adjusted Life Years (QALYs) and typically core criteria considers a utilitarian view whereby assessment is made against QALY maximisation from a societal point of view (Department of Health 2016, p. 65). However, specifically in the case of access to publicly subsidised pharmaceuticals, egalitarian conditions labelled within policy as 'rule of rescue' apply for individuals facing premature / avoidable death. In such cases resources are made available to individuals and these rules can circumvent QALY maximisation of societal benefits (Department of Health 2016, p. 123).

Rawlsianism is based on the work of John Rawls that seeks to ethically solve problems of distributive justice by representing "justice as fairness" (Matson 2013, p. 1). Rawls (1971, p. 266) states that society should be organised to allow the maximum amount of equal liberties upon its members and importantly for matters or resource distribution, that social and economic inequalities are only to be allowed if the worst off will be better off than they might be under an equal distribution. According to Ekmekci and Arda (2015) and Bommier and Stecklov (2002) the underlying moral theory purported by John Rawls is consistent with equity issues contextualised to health care resource distribution decisions of public monies.

According to Matson (2013) Rawls *"revives the social contract tradition of philosophers John Locke, Jean-Jacques Rousseau and Immanuel Kant, in opposition to utilitarianism"* (p. 1). Specifically, Ekmekci and Arda (2015) and Bommier and Stecklov (2002) argue, that whilst Rawls theory did not specifically discuss a right to health care as Rawls believed that a person's health is primarily an endowment of luck that one is born with, that Rawls theory can be nonetheless applied to the distribution of health care resources from the state in that Rawls identified that fairness in terms of distributive justice is *"achieved when each and every individual has access to the services she needs"* (Ekmekci & Arda 2015, p. 228). Furthermore, Ekmekci and Arda (2015, p. 229) reason that a just / fair society has a role in the fair distribution of primary goods, which Rawls defines as elements that support welfare that can amend inequalities arising from individual endowments. Similar to this view, the work of Daniels (1985) extended Rawls position to explicitly include distribution of health care, advocating that *"the health care system should be designed so as to bring everyone as close as possible to a decent minimum level of health, which he refers to as normal species functioning"* (Richard & Paul 2000, p. 328).

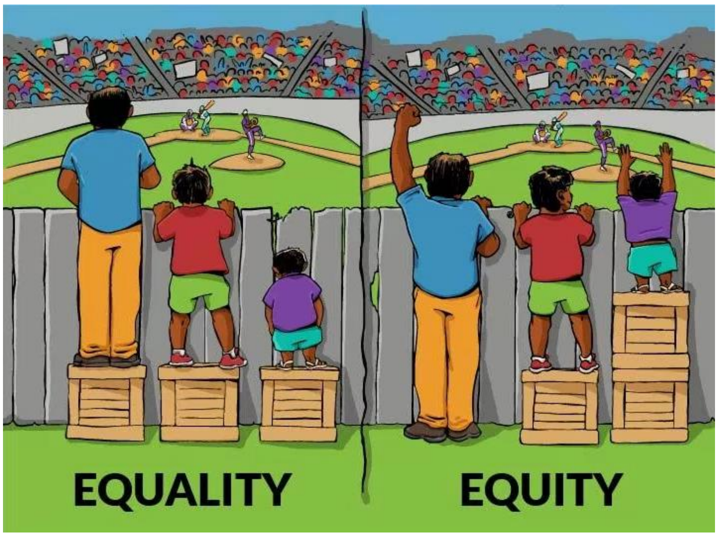
In Australia the Medicare principles of the universality of public insurance regarding access to public hospital services and subsidised private care (discussed in further detail in Chapter Three, page 94) are aligned with distributive justice principles outlined by Rawls and Daniel and that also of egalitarianism in the context that all people should have equal opportunity of access (Harris & Harris 1998; Harris et al. 2003; Spies-Butcher 2014). The effectiveness of treatment and maximising societal benefits are not prescribed in the Medicare principles (Council of Australian Governments 2011, p. 5). As such, as discussed on page 36, utilitarianism principles in Australian health care are largely confined to the cost effectiveness and efficiency assessments of medical technologies and interventions.

The HORSt is aligned with the distributive justice goals of Rawls theory in terms of seeking to afford an opportunity to improve upon health outcomes of populations on the basis of health care needs, via considering need in terms of capacity to benefit. Moreover, the HORSt is more specifically aligned to Daniel's position whereby the HORSt seeks to identify the resources required for populations to achieve an acceptable level of health outcomes. The following section explores this in further detail in the context of horizontal and vertical equity.

2.1.2 Horizontal and Vertical equity and health care needs

Addressing equity in terms of resource allocation decision-making, the health economics literature divides equity into two categories: (vertical equity) unequal resources for unequal health needs; and (horizontal equity) equal resources for equal needs (Mcguire et al. 1994; Mooney & Jan 1997; Morris et al. 2005). The following image, Figure 6 by Maguire (2016) used with permission via referencing and annotation to the source, is based on a meme that has been used extensively to communicate differences between equality and equity (Froehle 2016). Nonetheless this image can also illustrate the concepts of horizontal and vertical equity in the context of resource allocation for this study.

Figure 6 Horizontal and Vertical Equity demonstrated by the Meme of Maguire (2016)



In Figure 6, the three boys in the left side panel of the picture all have the same amount of resources, (one box each), to utilise to watch their sporting fixture. We can see the two taller boys are able to use these resources well. The tallest boy has a fantastic elevated view. The boy of middle height finds his resource adequate for viewing the game, yet the smaller boy is afforded a view through a crack in the fence.

As a starting point the height of the boys is what Rawls would describe as a natural endowment, factors that they were born with via a "natural lottery" (Resnik 1997, p. 427). These factors affect the boys' capacity to benefit from the resources they have. According to (Matson 2013, p. 1), *"although the natural lottery is neither just nor unjust, societies that base distribution of goods on it are unjust: There must be redress for the undeserved inequalities of birth and natural endowment".*

In the right-hand side of Figure 6, the resources have been redistributed. The largest boy's elevated view has been redistributed so that he still achieves the outcome of clearly being able to view the game, but the redistribution of the resources affords the smallest boy now with the same outcome as the other boys. That is: there is no more squinting for the smallest boy through the hole in the fence; nothing changes for the boy of middle height; and all three now achieve an unobstructed view of the game. The public provision of the distribution of healthcare in Australia can be considered metaphorically in similar terms. For example, the need for healthcare could metaphorically be a need to access a view of the game without obstruction and the health outcome being successfully seeing the game.

The literature reviews of Mooney and Jan (1997) and Macinko and Starfield (2002), find that health care needs have become a mainstay concept of defining equity with the majority of health economics literature focusing on needs within the context of horizontal equity. That is, equity is almost always defined in terms of equal access for equal needs (Mooney 2009; Rice & Smith 2001, p. 88), with the majority of health economics literature that has sought to define need has done so using health care utilisation as a measure of access to services as proxies of need (Macinko & Starfield 2002; Mooney et al. 1991). The rationale for doing so is that operationalising health care needs so as to define equity in the context of a workable resource allocation instrument is problematic, given that like equity, need is a value laden concept (Culyer 1995). Need therefore requires some sort of defining concept or measure itself. Guinness and Wiseman (2011, p. 253) state that there are three common conceptual definitions of health care need underpinning the definition of horizontal equity, being:

- equal access to health care for equal need;
- equal use of health care for equal need; and
- equal expenditure of health care for equal need

In the context of horizontal equity, if all three boys in Figure 6 on page 38 have the same need – to see the game, then the provision of the same resources, one box each, seems fair and equitable. After all, it could be argued that even the smallest boy can see the game via the crack in the fence, but just not as well as the other two. In this context horizontal equity is about putting fairness on par with equality with needs addressed via all the boys being afforded the same resources to access the game (the left-hand side of the picture). This is congruent with the Australian Medicare principles (page 94) regarding equality of access.

In the context of access within the definitions of health care need, the literature defines access via either the physical opportunity to use the health system, or to enter the health system, or in terms of financial barriers that affect the opportunity or entry of the system (Culyer & Wagstaff 1992). As discussed, that access can give rise to inequities. Strategies to address inequities purely around achieving equivalence of access would be aligned with the equality illustration of the left hand side of Figure 6 and would not consider need in terms of capacity to benefit and as per Matson's view, this is unjust based on funding for equal access does not correct Rawls' natural lottery of endowment through birth.

Mooney's explanation for the reliance of health utilisation as a proxy of need within funding models is because economics has an "obsession with quantification" (2009, p. 210) and utilisation represents ease of measurement. However, it is not unreasonable for instruments that apply the distribution of taxpayer funded resources to be quantified and indeed the transparent allocations of public monies logically require it. Moreover, it could be argued that utilisation which represents a key cost to the health system and is easily measurable through output-based funding mechanisms such as ABF, is a logical parameter for inclusion. Notwithstanding Mooney's criticisms, he concludes that the typical approaches to defining equity, equal access for equal needs where needs are proxied by utilisation, require new considerations. Significantly he asserts that need is a concept that can never be practically equalised and should be expressed in terms of capacity to benefit (Mooney 2009, p. 210).

Policy approaches in Australia that have focused on output-based funding models such as ABF and Medicare's fee for service and historical funding of inputs (Bennett 2012; Sansoni 2016) validates Mooney's summary. Furthermore, in Australia at the state level, both the former NSW Resource Distribution Formula (RDF) and the Queensland Resource Allocation Formula (RAF) were models that considered the health care needs of regional populations within their states. The models were used to redistribute funding according to needs that were approximated by access, where access was measured by variables that best predicted health service utilisation (Inter-Government & Funding Strategies 2005b; Queensland Health 1994). Importantly, however, the intent of both models was to tackle geographical inequities in funding, not health inequities (Ho 2001; Kirigia 2009). These models will be appraised in more detail in section 2.3 (page 46) which examines the effectiveness of different funding models to promote equity and efficiency.

Returning to the sporting field metaphor image of Figure 6 (page 38) if we consider more closely what Mooney (2009) championed as the best way to describe need; as capacity to benefit, the three boy's needs are quite different. In the left hand panel of the image, the one box afforded to the middle boy to access the system is adequate, yet it is very questionable that the taller boy needs this resource, which represents an opportunity cost to the smaller boy who, given the same one box resource has an unmet need. In other words, all three boys' capacity to benefit from one box is not the same. That is their need, which is to see an obstructed view of the game is very different. In this context, the equity shown in the right-hand panel of the picture is that of vertical equity, where the resource distribution shows unequal access for unequal need, (different amounts of boxes supplied to people who have different capacities to benefit from these resources). Importantly access is still available to all in the right-hand panel, yet the access is more allocatively efficient and equitable. The HORSt seeks to achieve this result for the distribution of public resources from states to LHNs and therefore in so doing so does not compromise the Medicare principles (page 94) regarding access. Doing so would be considered just using the Rawlsian principles discussed and the explicit extension of Rawlsian theory to health care advocated by Daniels.

Congruent to Mooney's position, advocating need to be considered in terms of capacity to benefit, multiple reviewers of the health economics literature suggest that health inequities should have both an opportunity and a potential to be addressed (Culyer 1995; Starfield 2001; Whitehead 1992). Considering peoples' capacity to benefit is therefore useful in considering the potential of improving health outcomes and tackling inequities and is demonstrated by the literature as better definition of health need than the reliance upon health utilisation. As such, the HORSt frames population health need in the context of vertical equity and via considering populations' capacities to benefit from resources. The approach for doing so is discussed further in section 2.3.3 Population needs-based models' (page 52).

Summary of key findings section 2.1 – Equity in Health Care

-HORSt as a resource distribution tool aimed at enabling improvements in health inequity and health outcomes is justified by theories of social justice of Rawls and Daniels and Egalitarian perspectives demonstrated by Australians.

- Horizontal equity approximating health need as use, predominately used in resource allocation funding instruments, places equity in the context of equality.
- Lack of use of vertical equity approaches to the problem represents a gap in the literature.
- Defining need in terms of vertical equity and capacity to benefit is a just goal for the health system congruent with the work of Daniels that advocates a health system should bring *"everyone as close as possible to a decent minimum level of health, which he refers to as normal species functioning*" (Richard & Paul 2000, p. 328).

2.2 EFFICIENCY IN HEALTH CARE

Against a backdrop of the global financial crisis (GFC), the OECD (2013) observed that for many economies there has been a significant shift from funding growth to productivity growth in the health sector with countries most affected by the GFC making the largest cuts to health expenditure. Australia, whilst faring typically better than most OECD nations during the GFC, was not immune to this trend with the Australian Institute of Health and Welfare (2014b) reporting that growth in real health expenditure in 2012/13 was at its lowest level since the mid 1980's. The implications of these health expenditure cuts have placed even more emphasis on efficiency.

In health economics, efficiency can be defined by three areas: technical efficiency; dynamic efficiency; and allocative efficiency (Duckett 2008a, pp. 325-6; Mcguire et al. 1994, pp. 76-7). All three efficiency types are interconnected. These concepts are introduced in this section and critiqued with respect to the effectiveness of funding models discussed within this chapter and contextualised to the development of the HORSt and the advancement of equity.

Technical efficiency, is concerned with the optimal production of health service outputs (Duckett 2008a; Segal & Richardson 1994). Dynamic efficiency is concerned with how well the health system as a whole can adapt to change and innovation (Duckett 2008a).

Allocative efficiency is concerned with ensuring that goods and services are allocated so as to maximize the welfare of the community via the optimal mix of goods and services from the best allocation of resources (Drummond 1989, p. 60; Duckett 2008a; Eagar et al. 2001, p. 18; Mcguire et al. 1994, p. 76). In public health care systems, the optimal mix of goods and services is also strongly interlinked with social justice pursuits of health care distribution as to whom and what type of services are supplied (Segal & Richardson 1994). Accordingly, allocative efficiency is often represented in the literature as being promoted by concepts of equity (Carr-Hill 1994; Carr-Hill & Sheldon 1992; Mooney 1983). Consequently, allocative efficiency involves taking into consideration three elements:

1. the technical efficiency of the health resources used in the production of health outcomes;
2. effectiveness of the outputs of health care to produce health outcomes; and
3. efficiency of the distribution of the health outcomes
   (Duckett 2004b, pp. 226-8).

It is important to consider that by their definitions, technical, dynamic and allocative efficiency can be pursued at many levels. For example, the optimal mix of goods and services could apply narrowly to the outputs of a hospital or more broadly to the outputs of a regional health service within a state or further still to the state or national level. The same can be said of a hospital's, state's or nations' ability to innovate through technical change or to achieve optimal production of outputs at the least costs.

The structural, funding and governance arrangements of the Australian health care system provide key challenges for efficiency strategies. For example, if the goal of the health system is to improve health outcomes, the optimal mix of services (allocative efficiency) within a state health system dominated by public hospitals is unlikely to be a panacea. This is because health outcomes are affected by the access to and interaction with all types of health services, not just to those found within the remit of the state public hospital system. Evashwick (1989, p. 30) describes and demonstrates an array of different integrated health services, "a continuum of care", as supporting the goal of optimising health care for populations. Eagar et al (2011), emphasises that allocative efficiency gains cannot be achieved without effective investment across the continuum of care. To this end the HORSt seeks to consider the tax payer funded and subsidised resources required for improving health outcomes across the whole continuum of care with the HORSt informing state resource distribution as a component within broader government funding, rather than trying to align health care needs to the confines of state budget resources alone. In doing so the HORSt seeks to promote allocative efficiency with respect to the definition of its three elements outlined by Duckett on the previous page.

2.2.1 The compatibility between efficiency and equity

The role of efficiency within a health system also needs to be considered as to where it fits in overall funding policy particularly with regards to equity. Efficiency has been considered by segments of the literature for many years as a trade-off with equity (Bevan et al. 2010; Earl-Slater 1999; Okun 1975; Williams & Cookson 2006). In particular, Williams and Cookson (2006), argue that health technology assessments all too often focus solely on efficiency gains at the opportunity cost of considering equity. Outlining the potential for conflict Guinness and Wiseman (2011) state:
"equity and efficiency are often conflicting objectives. For instance, it may be efficient to fund services concentrated in a small number of large centres but more equitable in terms of access to services to fund a larger number of dispersed smaller services" (p. 17).

Within the literature however, there is also a view that considers that the trade-off between equity and efficiency is *"semantically bad*" (Reidpath et al. 2012, p. 1). This is based on the established definitions of efficiency contextualised somewhat narrowly to optimality amongst functional relationships of resource inputs to outputs (production) and not in the context of resource distribution. In this regard the sort of efficiency that the conflict seeks to portray is of the technical / productive variety whereas, contrastingly, equity in the context of public health care funding as demonstrated in the literature is about fair resource distributions and or access associated with those distributions, typically to promote allocative efficiency. It follows that equity and efficiency in health care funding models are actually complementary whereby equity decisions determining resource allocation (funding) to optimise improvements in health outcomes promote allocative efficiency and maximising technical efficiency becomes the strategy in the provision (production) of health care to deliver the outputs.

Culyer (2006, pp. 1,155) describes the equity efficiency trade-off as "*bogus*" as the trade-off argument fails to acknowledge that the concepts of equity and efficiency are categorically different. Culyer affirms that:

> *"As separate categories of ethical consideration each ought to be given its due and proper attention. The suggested decision making context for combining equity and efficiency is a 'deliberative process' rather than an algorithm: a procedure that focuses minds on the real conflict – that between rival notions of what is to be regarded as equitable, which one may*

conjecture is best resolved through consultation and deliberation. A language that speaks of 'conflict' between equity and efficiency is unhelpful since, appropriately – and entirely conventionally – conceptualized, there is no conflict between them. Both are necessary ingredients in finding a satisfactory solution" (2006, pp. 1,158).

Guinness and Wiseman's previously quoted example of conflict between equity and efficiency is analogous to the public financing of small rural and regional health services in Australia. However, rather than conflict, it can be shown that this is an example of deliberate decision-making regarding equity promoting allocative efficiency and technical efficiency of the production and / or delivery of health care services. Due to scale, rural and or remote location and associated operating costs, small regional and rural services in Australia are known to be less efficient than larger and more urban services that can take advantage of economies of scale (Scuteri et al. 2011). These facilities are known as community service obligations (CSOs). CSOs comprise hospitals and/ or community health services and state and federal governments consider that states are obliged to provide them as in many cases no other health service such as private GPs for example, exist (Council of Australian Governments 2011). The public financing of CSOs is consistent with Culyer's argument of a deliberative process which to use words from Culyer's previous quote, is required to find a *'satisfactory solution'* of providing access that would not exist in a private market. Doing so promotes allocative efficiency and equity and so despite their known technical inefficiencies of services, CSOs are protected by national agreements between state and Commonwealth governments (Council of Australian Governments 2011).

In the context of state health funding models, the literature support for the complementary and deliberate relationship between equity and efficiency are important considerations for the development of the HORSt as an equity tool of resource distribution and a first stage in the two-step funding model. The second stage using ABF is an effective tool of technical efficiency. The next section critiquing the effectiveness of state-based funding models in Australia illustrates the HORSt in this role and also provides further examples that verify the compatibility between equity and efficiency components within funding models.

Summary of key findings section 2.2 – Efficiency in Health Care

- Allocative efficiency is often associated with concept of equity.
- Allocative efficiency requires considering technical efficiency of the health resources used in the production of health outcomes; effectiveness of the outputs of health care to produce health outcomes; and efficiency of the distribution of the health outcomes.
- Siloed nature of the health system and its governance arrangements are a key challenge for allocative efficiency of health outcomes.
- If the HORSt is to successfully be an instrument of equity, it will require being positioned as instrument of allocative efficiency and this itself will require considering the production of health system outputs across the continuum of care to produce health outcomes.
- Equity and efficiency goals are not always in trade off. Context and deliberate decision-making matters. The HORSt can work as a complementary tool of ABF.

2.3. EFFECTIVENESS OF PUBLIC HEALTH FUNDING MODELS

There are three main types of funding models that Australian state governments have used for funding regions that operate public hospitals. These are cost based, population needs-based and output-based(Broadhead 1991; Eagar et al. 2001; Hindle 2002). These models are examined in terms of effectiveness for addressing equity and efficiency in subsequent sections considering Australian and International literature.

Table 5, summarises Australian states' approaches to funding and also makes apparent that at times these three models have been used in conjunction with each other. Given this it may be more accurate to describe them as funding components rather than funding models per se.

Table 5 Australian state health funding models

State/ Territory	**Status quo** Cost based 'Historical' funding	**Equity models** Population needs-based funding	**Efficiency models** Output-based/ casemix funding
NSW	pre 1990 [1] / post 1990 elements remain[12]	1990-2012 -Needs-based model for allocating funding from state to area health services [1,2,3]	Casemix model between area health services and hospitals 2001[4] non mandated, made mandatory in 2008[5]. ABF 2012[6].
Queensland	pre 1991[7] / post 1991 elements remain[13]	1991-1995 -Needs-based model for allocating funding from state to regions[7,8]	Casemix model between regions and hospitals 1991-95[8] Casemix from 1995[8], ABF 2012[6]
Victoria	pre 1993[9] / post 1993 elements remain[11]		Casemix from 1993[9], ABF 2012[6]
South Australia	pre 1994[9] / post 1994 elements remain[14]		Casemix from 1994[9], ABF 2012[6]
Western Australia	Pre 1996[9] / post 1996 elements remain[15]		Casemix from 1996[9], ABF 2012[6]
Tasmania	Pre 1996[9] / post 1996 elements remain[16]		Casemix from 1996[9], ABF 2012[6]
Northern Territory	Pre 1997[10] / post 1997 elements remain[10]		Casemix from 1997[10], ABF 2012[6]
Australian Capital Territory	Pre 1997[9] / post 1997 elements remain[8]		Casemix from 1997[9], ABF 2012[6]

Table 5 References 1-(Services Development Branch 1990), 2-(Inter-Government & Funding Strategies 2005b), 3-(NSW Health 2005), 4-(Hindle 2002), 5-(Government Relations Branch NSW Health 2008), 6-(Council of Australian Governments 2011), 7-(Queensland Health 1994), 8-(Commonwealth Department of Health and Family Services 1997), 9-(Duckett 1998), 10-(Beaver et al. 1998), 11-(Department of Health and Human Services Victoria 2014), 12-(NSW ABF Taskforce 2013a), 13-(Queensland Health 2016, p. 6), 14-(SA Department of Health and Ageing 2016, p. 40), 15-(Western Australia Department of Health 2014, p. 53), 16-(Department of Health and Human Services Tasmania 2016).

Table 5 shows that with the exceptions of NSW and Queensland, all other states, commencing with Victoria in 1993, used casemix (episode or output-based) funding. This was similar to ABF but with different payment rules within each state to pay for public hospitals (Duckett 1998). Prior to casemix funding for these states, the funding model employed by all states was historical (Eagar et al. 2001).

2.3.1 Costs / input-based models

Cost based models are sometimes called historical funding because under this approach the funding arrangement is primarily based on the previous year's costs of production / inputs. Typically, the funder can make adjustments for population growth and other factors that may be considered relevant, but the underlying driver is the past year's costs (Broadhead 1991).

In preserving the status quo, historically determined models compromises dynamic efficiency, where innovation in health care can be stymied by the business as usual funding of inputs. This in itself can create poor alignment between population health needs and services, compromising equity and allocative efficiency. Furthermore, where historical payment is not linked to outputs, global historical budgets can encourage spending for the sake of maintaining budgets for inputs, compromising technical efficiency as well (Broadhead 1991; Eagar et al. 2001, pp. 72-3).

Table 5 illustrates that cost-based models were very much the modus operandi for many years in Australia prior to the commencement of output-based and needs-based funding. Importantly however, historical determinants still remain as necessary components within funding models that utilise output-based models. The rationale for this is explained further in the following section 2.3.2.

2.3.2 Output-based models (ABF / episode funding)

Output-based models pay for outputs. As described by Eagar, Garrett and Lin, (2001, p. 77):

> *"the idea of output-based funding is fundamentally simple. It is based on the view that outputs of the health system can be quantified and costed and that all providers should be paid the same amount for producing the same product".*

Output-based models left unchecked with no resource allocation guidance constraint, where payment is based on output, have an incentive to overproduce. Doing so does not advance equity or allocative efficiency. The models can be regressive in that they fund utilisation and not need (Broadhead 1991; Eagar et al. 2001, p. 78).

The National Health Reform Agreement (NHRA) required states to adopt ABF in 2012 as their funding model (Palmer & Short 2014). ABF also known as casemix or episode funding is an output-basedmodel and key efficiency reform (Independent Hospital Pricing Authority 2015a).

The Independent Hospital and Pricing Authority (IHPA) defines ABF on their website as

> *"a way of funding hospitals whereby they get paid for the number and mix of patients they treat. If a hospital treats more patients, it receives more funding. Because some patients are more complicated to treat than others, ABF also takes this in to account"* [*sic*] (2015a).

There have been indications in ABF documents that part of the rationale for ABF is that it will allow historical based funding to end (Health Policy Solutions et al. 2011, p. 12). As discussed in the first chapter, these views do not however consider the operationalised evidence that ABF is used only ***after*** a budget constraint for regions is established. As per illustrated in Table 5, the starting point for how much activity is to be funded is typically based on history, being the previous year's activity (Department of Health and Human Services Tasmania 2016, p. 27; Department of Health and Human Services Victoria 2014; Department of Health Western Australia 2016, p. 53; NSW ABF Taskforce 2013a; Queensland Health 2016, p. 6; SA Department of Health and Ageing 2016, p. 40).

As defined by the IHPA, ABF is fundamentally a currency for paying for hospital activity. Considering the extent of IHPA's definition, it is logical to conclude that ABF does not solve decisions of how resources should be equitably allocated within state public hospital systems in order to meet the health needs of the population. Consequently, it is not surprising to find state governments still relying on historical patterns of public hospitals' activity to inform the quantity and distribution of public hospital outputs to be purchased using ABF. As such, ABF should therefore be considered as a component of a broader funding model and not a state health funding model per se.

Output-based funding models do encourage technical efficiency (Auditor-General of Victoria 1998; Duckett 2008b; Eagar et al. 2001) yet it is apparent from the experience of ABF in Australia that they require a resource allocation constraint to determine how many outputs should be purchased. For these reasons, as shown in Table 5, NSW and QLD attempted to combine equity objectives and efficiency measures as a deliberative process during the life of their population needs-based models. Resource allocation funding decisions to regions were guided by population needs-based formulas and purchasing decisions within regions directed by episode / casemix funding (Government Relations Branch NSW Health 2008; Queensland Health 1994).

The current ABF model applies loadings in the payment calculations for each hospital service based on patient characteristics such as: people living in remote areas; people who identify as an Indigenous Australians; length of stay; and the type of service facility (type of hospital) (Independent Hospital Pricing Authority 2015b). Whilst considering patient characteristics could be seen as an additional payment to tackle health inequalities, problematically the ABF loadings are paid to the treating hospital on a per case basis. Given the highly mobile nature of flows of patients between regions, especially between rural locations to major city teaching hospitals, these additional payments can end up in regions where these inequalities are insignificant (Health Consult Pty Ltd 2011).

The effectiveness of output-based models, especially the casemix system in Australia that pre-dates ABF, has been well studied. The Auditor-General Victoria (1998) report into casemix funding, found that the funding model (casemix) achieved its major efficiency objectives for Victorian hospitals. Interestingly, the report highlighted questionable findings for equity.

> *"The majority of hospitals indicated that casemix funding had not improved access for socio-economically disadvantaged groups. Most hospitals advised that this outcome cannot be achieved by changes to the funding formula"* (p. 172).

The international literature of the limitations of casemix models corresponds with Australian examples, finding that equity and allocative efficiency can be easily compromised and overproduction can be incentivised. For example, Danish studies have provided evidence of casemix models that have led to overproduction with a focus on outputs rather than integrated care to the betterment of outcomes. Moreover, there was evidence of facilities preferring to treat less complex patients that are potentially easier and cheaper to treat. There was also incentives for facilities to perpetuate the status quo to preserve profit making and revenue streams at the opportunity costs for investment in innovations, (dynamic inefficiency) (Burau et al. 2018; Søgaard et al. 2015).

In Norway there is evidence of casemix facilitating gaming on the part of health service providers to seek greater reimbursement, in spite of governance arrangements to mitigate this from occurring (Lægreid & Neby 2016). In one of the largest international studies; a systematic meta review of 65 studies since 1980 across 10 countries (Australia, Austria, England, Germany, Israel, Italy, Scotland, Sweden, Switzerland and the United States of America) found that ABF was associated with higher rates of post-acute care hospitalisations and possible increases in readmissions (Palmer et al. 2014).

Reviews of the ABF experience in England, Germany, France, Finland and Ireland finds that like the Australian experience, ABF requires a budget restraint and strong governance arrangements above it to restrict its tendency to overproduce or game reimbursement (Baxter et al. 2015; O'Reilly et al. 2012). Aligned to this view the Canadian Health Services Research Foundation (2013) contended that ABF ought to be part of a blended funding model.

Summary of key findings section 2.3 - Effectiveness of Public Health Funding Models

-2.3.1 Cost based and 2.3.2 Output-based Models

Cost / historical based:

- Funding based on previous years activity do not encourage technical, allocative, or dynamic efficiency;
- Perpetuates status quo;
- Still used as starting point for funding regions by Australian States;
- Does not promote equity

Output-based/ casemix / ABF

- Purchasing tool that promotes technical efficiency of outputs
- Encourages tendency to overproduce outputs
- Does not promote allocative efficiency
- Cannot inform resource distribution or regional budgets of how much activity is to be purchased
- Requires a budget constraint / funding envelope – which has led to use in conjunction with Cost / historical models
- Does not promote equity

2.3.3 Population needs-based models

Population needs-based models seek to consider the health needs of populations. They are primarily used to guide resource distribution amongst populations on the basis of population needs and therefore are intrinsically aligned to the promotion of equity and allocative efficiency in funding allocations amongst populations (Eagar et al. 2001, pp. 74-6; Segal & Richardson 1994). Rice and Smith (1999, pp. 9-10) consider these models to be a form of risk-adjusted capitation scheme, to ensure equal funding for equal needs for all citizens within populations subject to risk characteristics of persons within populations that affect the demand and associated costs for health services.

Population needs-based models inform resource distribution to individual populations by using mechanisms that weight each populations need's characteristics relative to the whole population. Shares of funding from a central health authority to regions responsible for providing health care to regional populations are made on the basis of the weighted needs of each regional population (Eyles et al. 1991; McIntosh et al. 2010; Penno et al. 2013).

The proposed HORSt is a population needs-based tool. This section provides an overview of the literature for these models and in particular the former models used in Australia. First the effectiveness of these models to promote equity and health outcomes is examined. Second, the componentry within the models used to weight need is outlined. Three important issues arising from the literature that are contextually important to the development of the HORSt are then critiqued. These issues are that population needs-based models:

- are not designed to ensure technical efficiency of health outputs;
- rely upon utilisation as a default proxy of health need which is problematic for advancing equity and promoting allocating efficiency; and
- claim to promote allocative efficiency although make little attempt to empirically measure if this is the case.

2.3.3.1 Overview – the role and effectiveness of population needs-based funding models in improving health inequality

There is evidence that health outcomes can improve through the improvement of equity in funding that these models prescribe. For example in the UK, longitudinal ecological studies found that increases in funding to areas that had poorer social determinants of health resulted in closing gaps of mortality experienced by these populations compared to affluent areas (Barr et al. 2014).

However, that is not to say that greater funding under these models amongst populations facing adverse social determinants of health will always yield improvements in health outcomes. In Australia using a targeted population program for example, where additional specific funding has been directed to closing the mortality gap and improving the health outcomes of the indigenous population that are known to face significant socially determined barriers of health, little progress in terms of health outcomes improvement has been made (Browne et al. 2012; Commission on Social Determinants of Health 2008b; Department of the Prime Minister and Cabinet 2018).

The literature indicates that due to the exogenous nature of health care expenditure, analysis of the role and effects of health care expenditures for specific programs on health outcomes remains problematic. Often aspects of health program quality and effectiveness and accessibility are key issues that affect success (Barr et al. 2014; Bousmah et al. 2016; Crémieux et al. 1999; Martin et al. 2008).

Given the qualifiers in the literature pertaining to the effectiveness of funding related to outcomes for populations facing difficult social determinants of health, it is important to state that the role of population needs-based funding models is not seeking to cure the social determinants that give rise to poorer health outcomes or guarantee improvements in health outcomes. Rather, improving funding equity to address social determinants can act as an enabler for improving health outcomes and allocative efficiency by aligning resources to population needs (NSW Department of Health 2004; Sheridan et al. 2011). Furthermore, aligned with the literature introduced in Chapter One regarding health inequities and how social determinants of health affect outcomes and the Rawlsian theories of social justice extended upon by Daniels critiqued in this chapter (page 37), population needs-based funding models are a just mechanism of resource allocation. They can also provide transparency for taxpayers in ensuring that population needs are considered in the distribution of publicly funded resources (NSW Department of Health 2004, p. 32; Penno et al. 2013, p. 1).

The success of funding per se as an enabler to contribute to improved health outcomes is however well established. The OECD regularly monitors the contributing inputs for improved health outcomes and has found amongst OECD nations that health care expenditure growth over two decades between 1990 and 2010 contributed to the majority of the growth in life expectancy over that time (OECD 2017a, p. 38).

The role of population needs-based funding models as an enabler to improve health inequities and health inequalities in the international literature however, is more often an implicit goal, with explicit statements of purpose contextualised as per the discussion in the previous equity section (page 39), as facilitating horizontal equity via equal funding access for equal need. For example Ho (2001) and Kirigia (2009), find that the equity goal of the these models sought to equalise the same opportunity for financial access to state public health funding to regions based on factors that gave rise to health care utilisation.

Wenzl et al. (2015) suggest that from the perspective of models used in England, it is not clear as to whether these models promote equity. This is because the overarching goal is to more accurately predict the financial needs of providers (such as Clinical Commissioning Groups) to align budgets accordingly so that the capitation model is adequately financed for predictable demand for the population. Implicitly doing so and risk adjusting for the population needs to inform resource distribution, however, is an implicit lever for improved equity of funding access amongst populations.

Examples of purpose of the formulas from the international literature are as follows. In:

- New Zealand, the main goal of the original formula is to *"assist in achieving equality of access to core personal health services according to need*" (New Zealand Ministry of Health 1996, p. 6)
- Finland, the main equity aim of the formula used is to ensure "that each municipality has an equal opportunity to allocate more resources to servicing population areas with greater needs and less to areas with fewer needs" (Häkkinen 2005, p. S108);
- England, the foundational purpose of the formula was to "*redress disparities in funding between poorer and more affluent areas" and to promote "equal access for equal needs*" (Wenzl et al. 2015, p. 7);
- France, the intention is to facilitate equal access to health care via minimising socioeconomic and demographic barriers to access (Jourdain 2000); and in
- Australia in NSW, "the goal of the RDF is better equity in health funding. The RDF target share allocates funding required to meet the health needs of an Area Health Service's

(AHS's)[6] population" (Independent Pricing and Regulatory Tribunal of New South Wales 1998, p. 58)

The enabling aspect of reducing health inequities and improving health outcomes can be reasonably deduced from these examples of models' objectives to provide fairness in funding. In support of this, Rice and Smith (2001, p. 88) from their own review of the international literature find that population needs-based funding models have largely had two inherent goals of "*securing equity of health and to secure equity of access to health care*" and that from an operationalised perspective models have sought to contribute to a reduction in health inequalities via creating the "*potential for equal levels of care*", a horizontal equity approach.

Given the explicit goals of these funding models tied to improving the financial distribution of equal access for equal needs amongst regions and the literature's consensus on the difficulties of analysis to show effectiveness of these models in terms of reducing inequalities evident in improved health outcomes, it is not surprising to find that the literature regarding the effectiveness of these models has focused on demonstrating improvements in funding equity amongst regionalised areas. In England for example, the NHS RAWP has been deemed to be a success for bringing down budgetary excesses of relative advantaged areas down to a needs-based target budget and similarly by boosting the budgetary shortfall of relatively disadvantaged areas to their needs-based target (Gorsky & Millward 2018, p. 75). The Australian NSW RDF example now discussed also assessed effectiveness in this way.

During the period of operation of the RDF, the model in its various forms never actually set the budgets for each NSW regional area, with the redistributive shares of funding computed under the RDF applied to growth funding (Inter-Government & Funding Strategies 2005b; NSW Health 2005; Services Development Branch 1990). Setting budgets to precise RDF shares was considered to be too disruptive for the health services in the short term and so the RDF was applied to growth funding on top of historically determined budgets. Over time with the consistent application of growth funding guided by the RDF, the shares of funding of the AHSs were more closely aligned to population need than history and the RDF was considered to be effective in improving funding equity (Independent Pricing and Regulatory Tribunal of New South Wales 1998, p. 58).

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[6] AHSs in NSW were the regional forerunners of LHDs. In many cases the borders of the former NSW AHSs are identical to LHDs. Minor border changes do apply.

Identical to the approach used to assess the NHS RAWP success in England, the RDF's effectiveness considered how far away each NSW AHS's budget was from its targeted fair share of resources assigned under the formula. Prior to any guiding action of the RDF on NSW AHS budgets, the average population weighted distance from the RDF target for all AHSs was nearly 14% in 1990 with some AHSs receiving more than their fair share and some less. During its operational life up until 2010, successive NSW State Governments of all political views actively supported the NSW RDF for equitably guiding growth funding to local regions (NSW Health 2005; Services Development Branch 1990). An RDF target was established in the late 1990's so that the average population weighted distance from target for that all AHSs would be no greater than 2% of their equity share (NSW Department of Health 2003, p. 29). With the RDF in operation much of this funding inequity had been addressed and by 2005 the average weighted distance had been reduced to 1.8% (Inter-Government & Funding Strategies 2005b; Kirigia 2009; NSW Health 2005). This is illustrated in Figure 7 on page 57.

The change in the NSW AHSs budgets, illustrated in Figure 7 by the reduction in funding inequities to the distance from RDF target, does show that the RDF's application to growth funding was able to influence cost based / historical funding. Outside of the NSW government publications claiming the effectiveness of the RDF, only one external study, Kirigia (2009), sought to test its effectiveness. Kirigia's thesis considered alternative measures of health need using socioeconomic, demographic and premature mortality data. She found that funding inequities across regions nonetheless remained. A further issue noted was that the RDF did not consider funding inequity within the AHSs. However, the RDF was never intended to do so.

The overarching effect however, of the discontinuation of the RDF as an equity funding tool is also apparent in Figure 7. The immediate years following its non-use show a ballooning of the distance from target to be more than three orders of magnitude away from the stated policy objectives of 2%. Independent external auditors found the primary reason for reversing much of the gains made in funding equity over the 20 years to 2010 was directly attributable to state government funding allocations made to LHNs in 2011 that had not considered RDF calculated needs-based shares (Health Policy Analysis 2012, p. iii).

Figure 7 NSW Area Health Service Weighted Average distance from RDF Target

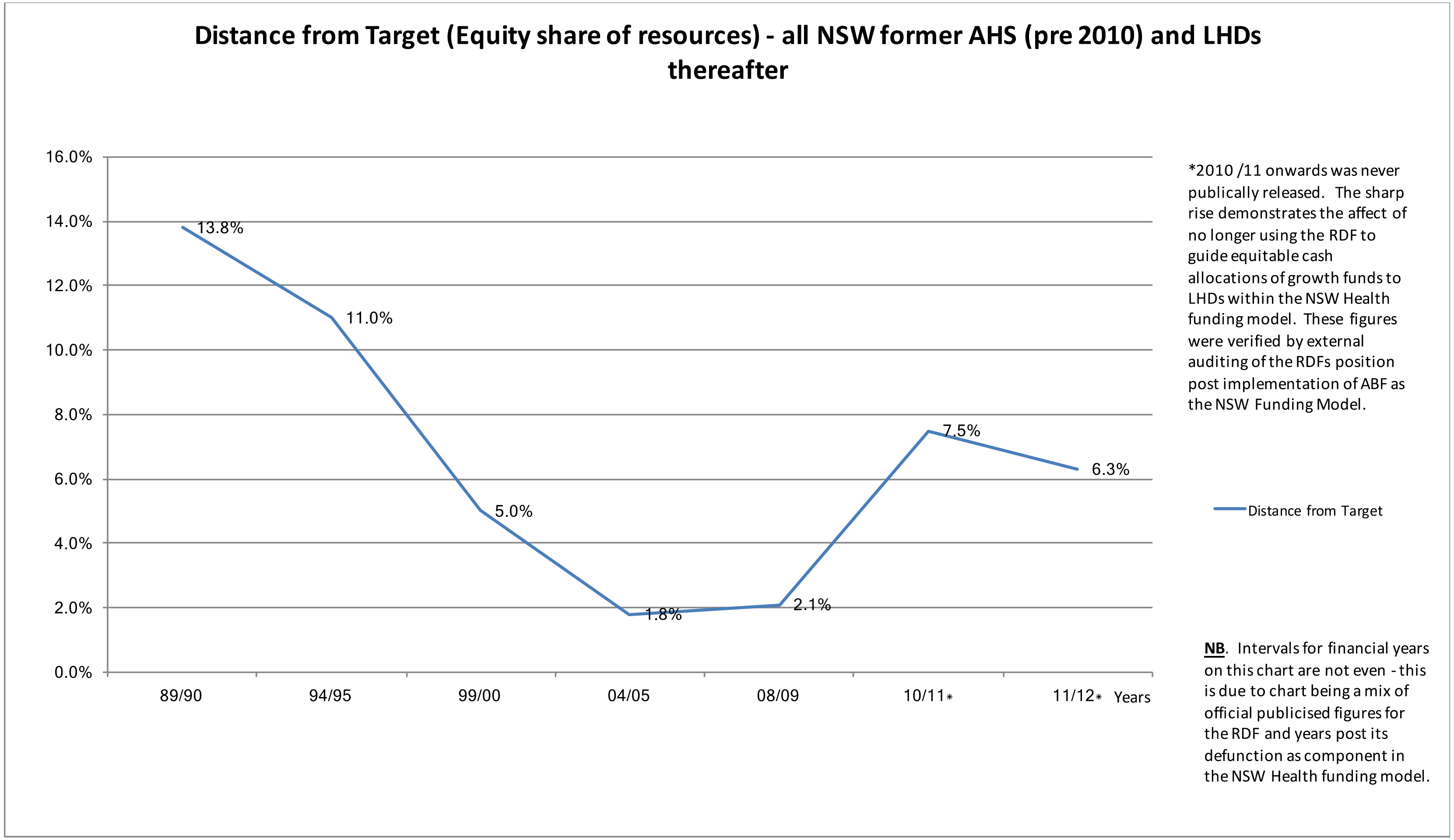

Figure 7 adapted from *NSW Resource Distribution Formula Technical Paper* (Inter-Government & Funding Strategies 2005b, p. 9), which showed publicised Distance from target figures between 1989/90 and 2004/05. 2008/09 figures were publicised through the course of NSW State Parliamentary business (Garling 2008, pp. 7-8; Smith 2010). 2010/11 and 2011/12 figures were verified by an external audit of the RDF (Health Policy Analysis 2012).

The application of the HORSt to growth funding congruent with the operation of the former RDF is discussed in the concluding chapter. As a funding enabler of reducing inequity and improving health outcomes, assessment of the HORSt's effectiveness would face an identical set of challenges as described in the literature. As such assessment of effectiveness logically should follow the RDF and RAWP methodology. However, such assessment would involve a long-term commitment to utilising the HORSt.

2.3.3.2 Overview of componentry and extent of population needs-based models

The international literature pertaining to the construction and operation of population needs-based funding models demonstrate a high degree of variability in the componentry and comprehensiveness that makes up the models. For example, the NSW former RDF by the time of its abandonment in 2012 was a very comprehensive model that developed health need indicators (HNIs) from socioeconomic determinants (all of which sought to explain utilisation) for a variety of health programs. The health programs are not disease specific. They satisfy core budget areas of state public health expenditure, predominately public hospital services. i.e. These are:

- Acute;
- Emergency Department (ED);
- Rehabilitation;
- Outpatients;
- Community;
- Mental Health Admitted and Ambulatory;
- Renal, Palliative Care;
- Teaching and Research; and
- Population health programs.

(Health Policy Analysis 2012; Inter-Government & Funding Strategies 2005b)

The HNIs differed for most of the programs. The final needs-based shares of state health funding for each NSW AHS / LHN was computed considering each program's HNI in conjunction with adjustments for cost related issues for facilities, speciality state-wide services, dental hospital and small hospital operating costs, HIV / aids costs, net patient flows between other states and NSW and net patients flows between NSW AHSs (Inter-Government & Funding Strategies 2005b; Slater & Marshall 2012).

In contrast to the NSW final model, the original model used in England commencing in 1976[7] which is widely accepted in the literature as the founding population needs-based model for allocating health resources amongst populations, utilised a simple standardised mortality ratio (SMR), (a health outcomes approach) to allocate funding to different areas on the basis of need (Gorsky & Millward 2018; National Health System 1976). All jurisdictions' models have gone through evolutions. For example, by 1997 the English model had become more sophisticated, utilising socioeconomic status variables in conjunction with SMRs and an additional health outcomes parameter consider long term illness, as the basis of a needs-based formula that explained differences in demand and costs for general and acute services. Similar to the health program approach used in NSW, the later English model also used a separate multivariable model of SMRs and a different set of socioeconomic indicators as predictors of differing program service demand and costs (Diderichsen et al. 1997).

Rice and Smith (2001, pp. 103-5) define the componentry of these formulas in the context of factors that give rise to necessary risk adjustment for population needs which give rise to health system utilisation and costs. They summarise these risk components as:

- demography (age, sex);
- ethnicity (for example, indigenous status);
- employment / disability;
- geographic location;
- mortality;
- morbidity;
- social economic factors (such as unemployment, marital status, housing quality, income, family structure).

Rice and Smith's categorisation is not however a quintessential list, where it could be argued that there is overlap between categories, for example aspects of disability could be considered socioeconomic and a more extensive or shorter list of categories could be contrived. Penno et al. (2013, p. 4) state in the context of their own review of the international literature, that the construction of population needs-based formulae typically starts with the concept of:

"aligning allocations with factors that explain differences in demand (utilisation); by implication that these factors reflect differential health need. The factors are represented by variables that represent

[7] This model is often referred to as the RAWP in reference to the Resource Allocation Working Party that recommended it.

components of health need that can be defined by two broad categories: demographic indicators which act as proxies for need and more manifest measures of need such as disease status."

As an example of the extent of variables that have been used as needs-based components that explain health system use, a summary overview of 10 international models variables is presented in Table 6 on page 62. Most of the data applied as predictors of utilisation come from country's official census statistics or official data collections. Census statistics, whilst typically not collected annually are constructed for most countries to be relatively stable metrics overtime and can therefore be of use in models to inform prospective budgets (National Health System 1976; Rice & Smith 1999; Technical Advisory Group for Resource Allocation 2016).

Sweden and England have considered methodologies that seek clinical person-level data to predict needs via utilisation (Andersson et al. 2011; Dixon et al. 2011). The Nutfield Trust for example has developed a methodology for the English NHS and describes this approach as "Person-based Resource Allocation" (Bardsley & Dixon 2011) . This data is usually of a diagnostic nature and examples are found in Table 6 in the column labelled 'Clinical'. There are some key limitations of this approach including;

- that data may not be available on all members of the population or enough members of the population to be representative of health needs;
- there are often significant delays in the availability of the data and
- that they may not fully account for socioeconomic effects on need for health services

(Andersson et al. 2000; Health Policy Analysis 2014b, p. 6)

Table 6 provides a general overview of the type of variables that have been used in jurisdictions at various times. It is not intended to show all of the nuanced details of variables which can vary within specific health program sub structures of population needs-based models and which are subject to constant revision by their jurisdictions.

Operationalising variables like those shown in Table 6 to represent need within population-based formulas often involve statistical methods such as regression analysis which is used to consider correlations between variables and a proxy of health need (utilisation) (Asthana et al. 2004; Carr-Hill & Sheldon 1992; Health Policy Analysis 2013). The correlation coefficients of variables from the regression that are found to explain variations in utilisation can be used to inform population needs-based weightings with the funding formula to equalise the funding of health needs for each geographical area. Applied to a budget the health need indices can provide a weighted population needs-based share of funding for regions (Carr-Hill & Sheldon 1992; Inter-Government & Funding Strategies 2005b).

Table 6 Examples of needs-based components used to explain health system utilisation in population needs-based funding models

Country / Jurisdiction	**Component factors used that correlate with health system demand / costs (utilisation)***						
	Demography	**Socioeconomic**	**Geographic**	**Ethnicity**	**Epidemiological / Health Outcomes**		**Clinical**
					Mortality	***Morbidity / other***	
England Weighted capitation model - used for allocating to Clinical Commissioning Groups (CCGs) (replaced Primary care trusts). Separate applications for different clinical programs. NB for brevity only the Acute program measures are shown in this table (NHS Analysis and Insight for Finance 2019; NHS England Strategic Finance 2014)	5 yr age bands 0 to 85+ yrs CCG population size	Persons without qualifications; Education retainment; Pension claimants; Income deprivation affecting children; and Disability living allowance claimants.	Supply index; Mean Waiting Times; Distance to outpatient services, admitted services; Numbers of GPs; and Accessibility scores for acute and outpatient provider capacity; Ages / sex standardised CCG population growth rates		Age-standardised death rates / standardised mortality rates (SMRs)	Low Birth Weights; Standardised limiting chronic illness	
England (person-based model) Not implemented – proposed (Dixon et al. 2011)	Age	Persons without qualifications aged 16-74; People living in social housing; Urban professionals Disability living allowance claimants.				Asthma prevalence	157 ICD 10 codes
Scotland Weighted capitation model - geographical / population-based with some person-based elements Separate applications for different clinical programs (Technical Advisory Group for Resource Allocation 2016)	5 yr age bands 0 to 90+ yrs	<u>Mental Health program: </u>% of people living alone; and % living in social housing. <u>Maternity program:</u> mean house prices	<u>Maternity program:</u> urban-rural index		<u>***NB.** </u>SMR used only for the Acute and GP prescribing programs does so without any direct linkage or correlation to utilisation.	<u>Acute and GP prescribing program:</u> Standardised limiting chronic illness rate	<u>Acute and GP prescribing program</u> Morbidity and life Circumstances index – defined by ICD 10 clinical codes

Country / Jurisdiction	Component factors used that correlate with health system demand / costs (utilisation)*						
	Demography	**Socioeconomic**	**Geographic**	**Ethnicity**	**Epidemiological / Health Outcomes**		**Clinical**
					Mortality	***Morbidity / other***	
Northern Ireland Regional capitation formula Separate applications for 9 different clinical programs and sub programs. **NB** For brevity only the Acute program measures are shown in this table: (DoH Statistics and Research 2014)	5 yr age bands 0 to 85+ yrs	Proportion of 65+ not claiming Attendance Allowance; Northern Ireland Multiple Deprivation Measure Score; Standardised Birth Rate; Proportion of all households not owned outright; Proportion of households with 2 or less children; Proportion of all females aged 45-64;	A separate rurality formula is applied across programs for rural areas			Standardised self-reported not good health for all persons Standardised Limiting Long-Term Illness Standardised Cancer Incidence Rate Standardised Birth Rate	
Italy Somewhat population-needs-based and only partially weighed. Intended for determining fair shares of funding equity across 21 regions of Italy. As of 2014, not fully implemented due to political disputes amongst regions. (Caruso & Dirindin 2012; Ferré et al. 2014; Poscia et al. 2018)	Use of health services by age. Funds for prevention are allocated to regions on the basis of the (unweighted) resident population.		Rural areas		***NB** Social deprivation and the health status of the population as assessed by the mortality rate and are not empirically correlated or linked to demand / costs / utilisation		
Australia NSW RDF Population weighted model for allocating state heath funding to regional areas – made defunct in 2012. (Inter-Government & Funding Strategies 2005b; Slater & Marshall 2012)	Age / sex; 5 yr Age groupings to 85+ yrs	<u>Acute program:</u> SEIFA Index of Occupation & Education. <u>Population Health, Primary & Community, Outpatients and Emergency Departments:</u> SEIFA Index of Occupation & Education; and % Homeless people. <u>Oral Health program:</u> Health care card holders	<u>Acute, Population Health, Primary & Community, Outpatients and Emergency Departments:</u> Accessibility and Remoteness Index of Australia (ARIA+)	<u>Acute, Population Health, Primary & Community, Outpatients and Emergency Departments:</u> % Aboriginal & Torres Strait Islanders	<u>Acute, Population Health, Primary & Community, Outpatients and Emergency Departments:</u> Standardised Mortality ratios of premature deaths <70 yrs	<u>Oral Health program</u>: caries in children 0-14 years and adults. <u>Maternity program only:</u> Fertility rate mothers <35 years	

Country / Jurisdiction	Component factors used that correlate with health system demand / costs (utilisation)*						
	Demography	**Socioeconomic**	**Geographic**	**Ethnicity**	**Epidemiological / Health Outcomes**		**Clinical**
					Mortality	***Morbidity / other***	
New Zealand Population weighted model for allocating state heath funding to regional areas (Penno et al. 2012; Penno et al. 2013)	Age / sex; 5 yr Age groupings to 85+ yrs	Deprivation quintiles from Deprivation index		Maori, Pacific, Other			
Sweden Stockholm County Population weighted model for allocation to 9 Health Care Authorities. (Andersson et al. 2011; Andersson et al. 2000).	Age / sex 0, 1-15, then 20 yr age groups to age 65, 66-75, 76--80,81-85, 85-90 and 90+	Marital status (single, living with children or married); Type of housing (small, other); Occupation; and Education (lowest education / upper secondary).					Considered but not yet implemented a range of Costly Diagnostic Groups (CDGs)
Canada Ontario Health Based Allocation Model – part of mixed funding model with casemix – applied to Local Health Integration Networks (LHINs) Person based activity informs Resource Intensity Weighting for LHINs population-based shares (Ontario Ministry of Health 2018; Rachlis & Gardner 2008)	Age Sex	Socioeconomic status - income					Last three years clinical use / informs severity index
Netherlands Dutch Risk Equalisation Model - Risk-adjusted payment to insurers from employers and Government for population need characteristics (Douven 2004; Eijkenaar et al. 2019; Ministry of Health 2008)	20 Age categories 5 yr span and 90yrs +	Income source; Average Income; Marital Status	Urbanisation; Proximity of access per 1,000 pop within 25km radius of facilities	Non-western migrant population	Standardised death probability		Primary Care Cost groups; Diagnostic groups

2.3.3.3 Populations needs-based funding models cannot ensure technically efficient health outputs

A key limitation of population-based needs models is that whilst they can promote equitable funding distribution for population need, the models have no mechanism to ensure that the funding will be spent in a technically efficient manner to address population needs (Eagar et al. 2001, pp. 76-7; Hindle 2002; Kirigia 2009). This criticism of the limits of population needs-based funding models could be viewed in support of the trade-off discussed in the preceding section between equity and efficiency. However, as per Culyer's arguments presented on page 44 to the contrary, alleviating this criticism involves deliberate positioning of a population needs-based funding tool as a first stage component of resource distribution within a broader funding model that also involves a secondary mechanism that promotes technical efficiency.

As illustrated in Table 5 on page 47, both the RDF and QRAF were not always used in isolation as state funding models. Cognisant of the limitations of population needs-based models with regards to not being effective instruments of ensuring technical efficiency of outputs, NSW and QLD employed them as the first step in a combined funding model. Redistribution of resources under the first step afforded areas with higher population needs with higher shares of funding and vice versa. Casemix funding, called episode funding by NSW and QLD at the time, was used as the second step that informed each area's hospitals technical efficiency (Government Relations Branch NSW Health 2008; Hindle 2002; Ho 2001; Schneider 2005). This demonstrates that the HORSt as an instrument of population needs-based funding can be operationalised as a first step in the funding model with ABF acting as the second.

It is important to note that there is a body of Australian literature that is somewhat unaware of the two-step arrangement that combined RDF and episode funding in NSW. Palmer and Short (2014, p. 346), state for example in the context of casemix funding (the forerunner of ABF), that there was:

"continuing opposition to the use of casemix funding in NSW Health Department. Part of the reservations about the application of this new method of hospital funding stemmed from the fact that the department had devoted considerable resources to securing greater equity between geographical areas in the allocation of health service funding."

Not only does this view not acknowledge the use of episode funding alongside the NSW RDF since 2001 (NSW Health 2005, p. 4), but it is reasonably possible to deduce from this view the falsehood that a state health funding model can only consist of needs-based or episode based funding, not both. Such a view is in conflict with the international literature presented in the casemix funding section on page 51. Outside of Australia, Ontario Canada is a good example of where population needs-based funding and casemix funding are combined within a funding model. The model utilises three components being:

- Global Budgets – elements of cost / historical funding; and
- Health Based Allocation Method (HBAM) – a population needs-based funding tool; and
- Quality Based Procedures – quality adjusted form of casemix

(Palmer et al. 2018).

Whilst the RDF had successfully coexisted as the first step in a two-step funding model with episode funding since 2001, the NSW Ministry for Health in 2011 commenced ABF and promptly abandoned RDF. There has never been any documented statement by the NSW Government as to the official decommissioning of the RDF (Slater & Marshall 2015). In the absence of this it would be reasonable to deduce in NSW, that RDF was replaced by ABF, especially with the marketing of the new NSW Health funding model to the NSW health system being exclusively presented in terms of ABF (NSW ABF Taskforce 2013a, 2013b).

At the cessation of using the NSW RDF and the commencement of ABF, health needs components known as the health need indices (HNIs) were reviewed and were retained in the NSW Health funding model for making minor adjustments to the historical volume of outputs to be purchased using ABF (NSW ABF Taskforce 2013a). A former NSW Ministry of Health senior bureaucrat described these components as an “equity lens” (Bolevich 2013). In reality these components have a negligible role and effect on resource distribution in the new model (Slater 2014) and as such they do not improve health inequities, nor do they act to steer funding away from historically determined resource distribution. These components, a revised version of the former health need indices from within the RDF, are still based on variables that predict utilisation to represent need. In fact, NSW Health aptly now calls these variables ‘Expected Health Utilisation Indices’ (EHUIs) (Health Policy Analysis 2014a, p. 1).

The use nonetheless of the EHUIs further demonstrates the compatibility of use of an equity tool alongside ABF. For successful operationalising of the HORSt, it will be necessary to emphasise the dual, separate, although complementary functioning of the HORSt alongside ABF.

2.3.3.4 Utilisation is a problematic default proxy of population health need

The concept of need is a value laden concept (Culyer 1995, p. 727). As such, a key challenge for population needs-based funding models is developing a robust measure of relative population needs that can be operationalised into a funding formula. As outlined in the preceding equity section (page 39), a summary of international literature find that there has been a prolonged use of health care utilisation within needs-based population funding models as a proxy of health need and utilisation expressed as equal access can give rise to inequities (Barr et al. 2014; Carr-Hill 1994; Carr-Hill & Sheldon 1992; Mooney 2009; Mooney et al. 1991; Sheldon et al. 1993). Problematically, defining health needs in terms of access to services and utilisation requires some sort of proxy measurement itself for it to be meaningful in terms of policy setting and resource allocation. Specifically, as shown in the examples provided in Table 6 (page 62), population needs have been largely approximated by access, where access, was measured in formative constructs by variables which include socioeconomic determinants of health that best predicted health service utilisation.

Carr-Hill and Sheldon find that measures of social deprivation found to correlate to health needs through regression are "illusionary" (1992, p. 117). Underlying this assertion is that as a proxy of health need; utilisation as the dependent variable in regression modelling is problematic, reflecting both patterns of available supply and satisfied demand and therefore not health need. Unsatisfied demand, not visible within utilisation, can be representative of unmet needs and health inequalities.

Carr-Hill (1994) and Rice and Smith (2001) also highlight in direct contrast to unmet need that supplier induced demand can be represented in utilisation statistics. In such cases the utilisation is inefficient, unnecessary and contains over-servicing. This too creates difficulty for population needs-based formulas relying upon use as the measure of needs.

The NSW former RDF made efforts to factor out influences of endogenous supply on utilisation so as to try and uncover underlying need factors that affect levels of demand for services (Health Policy Analysis 2013, p. 14). To do so, the NSW RDF considered that private sector hospital activity to a varying degree, depending on the type of activity, is substitutable to public hospital services. In developing the dependent variable in the regression for the HNIs which was based on standardised cost weights for inpatient activities, the NSW RDF applied a discount for private hospital activities (Inter-Government & Funding Strategies 2005b, p. 45). The discount applied to the standardised cost weights in the former RDF had the effect of reducing the relative health needs in populations where private services usage was higher.

Notwithstanding the efforts made in the NSW RDF model to improve upon utilisation as a proxy of health need, it is clear from Mooney's summation of the literature reviewed in the equity section of this chapter, that the over reliance of utilisation as this proxy represents a gap in the literature, whereby needs are contextualised in terms of horizontal equity and resource distribution amongst populations is about equivalence of access for equivalence of need.

The gap in the literature described asserts that health needs are better represented by capacity to benefit, rather than utilisation. Whilst this gap will inform the approach outlined for the HORSt, it is nonetheless important to contextualise utilisation's use in these models to the models' individual purposes. To not do so would be to assume (incorrectly) that the utilisation approach to population health needs-based models is always lacking. This is not necessarily the case. These models' primary use is to guide resource distributions from governments to regionalised areas. The context of deliberate policy making to do so is crucially important. For example, if the contextualised goal is to pursue vertical equity in funding shares to populations so at to enable improvement in health inequalities and health outcomes via considering populations capacity to benefit to achieve outcomes, a non-utilisation approach to health need in light of the gap in the literature can be justified. However, if the goal is to best predict health system costs under a risk (needs) adjusted weighted capitation model so as to enable equal opportunity of access (horizontal equity) then an utilisation approach to health needs (representing access), congruent with the plethora of models that have set out to do so is satisfactory.

In addition to context, practicality is important for operationalising these instruments. The utilisation measure of health need approach is popular due to its simplicity and its relationship with funding driven by expressed demand. Logically, given this simplicity and intuitive connection to health system costs, utilisation applied in such mechanisms affords governments with a degree of transparency that can support public accountability. In contrast, a health outcomes approach for population needs-based modelling is not without difficulty. Section 2.4 (page 72) outlines the alternative variables that could be used in establishing measures of population outcomes that are robust enough to support these instruments. The HORSt will utilise a measure of population health status as a proxy of health outcomes and health needs.

The HORSt population-based shares of funding will be compared with the most recently used equity tool in NSW, the NSW EHUIs (Expected Health Utilisation Index). Whilst the HORSt is a different approach, both models acknowledge via the literature the importance of considering social determinants as predictors of the proxied need variables. The comparative resource distribution shares of both models applying social determinants that predict needs (however differently defined) therefore may produce similar results.

2.3.3.5 Do population needs-based models actually improve allocative efficiency?

As stated in the efficiency section (page 43), the literature indicates that population needs-based models promote allocative efficiency via improvements in equity aligned to a more appropriate mix of resources that can be applied to health needs. However, in order to explicitly promote allocative efficiency, it is logical to consider a measure or estimate of allocative efficiency so as to guide the redistribution of population needs-based funding shares to do so. None of the extensive international and Australian literature searched and examined for this literature review indicates any population needs-based funding models attempting to estimate or measure the underlying allocative efficiency of the production of health outcomes.

Revisiting the axioms required for allocative efficiency outlined by Duckett (page 43), allocative efficiency involves consideration of three elements. These are:

1. technical efficiency of the health resources used in the production of health outcomes;
2. effectiveness of the outputs of health care to produce health outcomes; and
3. efficiency of the distribution of the health outcomes.

Considering these definitional elements and the international literature's critique of population needs-based funding models, the *a priori* view in the literature for the promotion of allocative efficiency is difficult to *explicitly* sustain. As outlined, population needs-based funding models:

- cannot control the technical efficiency of the health resources used in the production of health outcomes and require a secondary mechanism to work in union to promote technical efficiency such as ABF;
- cannot influence the effectiveness of the outputs of health care to produce health outcomes; and
- as an enabling instrument for improving funding equity, cannot guarantee efficiency of the distribution of health outcomes especially when these models tend to rely upon utilisation as a proxy of health care need.

Whilst there may be an *implicit* improvement, promotion, or enabling of allocative efficiency through these models' redistributive action of resources to a more appropriate mix of resources to support needs (no matter how defined), the lack of formal measurement of allocative efficiency contextualised to health outcomes therefore represents a gap in the literature. In response to this gap, establishing a population needs-based tool where the allocative efficiency of desirable level of health outcomes can be calculated is a more transparent approach to the problem. Populations that are allocatively efficient in the production of desirable health outcomes could represent a benchmark. Redistributing funding to populations that have poor allocative efficiency compared to the benchmark, due to poor social determinants of health that affect allocative efficiency, could act as a funding enabler to promote allocative efficiency of better health outcomes. The HORSt seeks to achieve this, although to do so requires the development of a proxy representing health outcomes of populations that can be used as a proxy of population health needs. The next sections in this literature review outline alternative proxies to utilisation for health needs and also consider a benchmark to support establishing the measurement of allocative efficiency and resource distribution.

Summary of key findings section 2.3 - Effectiveness of Public Health Funding Models

2.3.3 Population needs-based funding models:

- implicitly act as funding enabler to promote equity and allocative efficiency;
- in acting as a funding enabler, are not seeking to guarantee improvement in equity or outcomes;
-are a just method of resource allocation aligned to social justice theories of Rawls and Daniels;
-afford transparency of resource distribution for taxpayers;
-cannot promote technical efficiency of health outputs;
-can act in partnership with casemix funding (which can promote technical efficiency);
-resource distribution best applied to growth funding to gradually align regional shares to population needs;
-effectiveness is largely assessed by improvements in regional shares of funding distance from needs-based shares of funding
-typically, have sought to measure need as health system use and have used variables that predict utilisation as population weights to inform regions shares of funding; and
-have not sought to explicitly measure the allocative efficiency that they claim to promote.

Specific gaps in literature:

- utilisation approach to health needs in population needs-based funding models aligns to horizontal equity;
- if the literature's recommendation that need should be expressed by capacity to benefit (vertical equity) is pursued, alternative measures of need are required;
- do not explicitly measure allocative efficiency –if allocative efficiency is to be promoted it ought to be measured / estimated and this will require contextualisation of allocative efficiency to the production of health outcomes.
-require partnership with ABF, where ABF continues to promote Technical efficiency of outputs

2.4 PROXY MEASURES OF HEALTH OUTCOMES THAT CAN BE USED AS MEASURES OF POPULATION HEALTH NEED FOR USE IN THE HORSt

In order to advance the literature's recommendations to position need in the context of vertical equity and define it via capacity to benefit, the HORSt will consider different health need proxy alternatives to utilisation. This section now considers measures of health outcomes that may be useful for approximating need for health outcomes in the HORSt.

In considering measures of population health needs, it is also useful to examine Bradshaw's view of societal needs. Bradshaw (1972) outlines four axioms of social need. The more axioms that apply to measures of need, the stronger the need. These axioms are:

- Normative need – need defined by experts and evidence;
- Felt need – need representing the perceptions and experiences by the individual;
- Expressed need – demanded need (observed access of services); and
- Comparative need – needs identified by comparison of services or comparison of access to services.

In the context of the need for health care, expressed and comparative need are represented in utilisation statistics; however, felt need and normative need are not. A health outcomes approach to need could ideally encompass more of these axioms.

The importance of measuring health outcomes in the context of funding has become more important to health systems that have previously focused on improving the technical efficiency of the delivery of health interventions (outputs) and now wanting to ensure that interventions yield value in improving health outcomes (Australian Commission on Safety and Quality in Health Care 2019; Colldén & Hellström 2018; Porter 2009).

In Australia health outcomes are defined as:
"a change in the health of an individual, or a group of people or population, which is wholly or partially attributable to an intervention or series of interventions" (Sansoni 2016, p. 7).

Sansoni (2016, p. 8) identifies that health outcome measures can take the form of:
"clinical/biomedical indicators, health outcome-related performance indicators, standardised clinical assessments and patient reported outcome measures (PROMs)".

For developing a measure for the HORSt, it is important to recognize that these health outcome measures collected for individuals need to reflect the population. In this situation Sansoni outlines with respect to the health outcomes definition, the change in health status of individuals can be aggregated at the population level and a health outcomes performance indicator such as
"the rate of avoidable adverse events, hospital acquired infection rates, time to treatment rates, return to theatre rates and unplanned readmission rates" can be used.

In moving towards the HORSt approach, measures that give an overall representation of the health status of the populations' that can be then considered in the context of populations' capacity to benefit from resources (health needs) so as to afford the opportunity to improve the health outcomes of the population are sought. In other words, a health outcomes performance measure as measure of population health status will be used as proxy for population health outcomes and for representing health needs. Such an approach is somewhat congruent with the epidemiological / health outcome measures used as needs based components of the population needs based formulas presented in table 6 on page 62. However, as discussed, a distinguishing feature to that of the HORSt, is that those formulae used those components to explain utilisation as need.

Health status is defined as;
"a generic term referring to the health (good or poor) of a person, group or population in a particular area" (Segen's Online Medical Dictionary 2011).
This is a holistic concept representing the wellbeing of a person and is often measured by life expectancy or self-assessed health status, degrees of functioning, illness and mental wellbeing (Australian Institute of Health and Welfare 2015c). As a fundamental goal of providing health care is the improvement of the health status of the population (Palmer & Short 2014, p. 15), this is a suitable concept for the research. Measurable differences in health status amongst geographical populations can inform equitable policy regarding resource distribution. Furthermore, Eagar, Garrett and Lin (2001) consider that the health status of geographical populations is an important consideration of health care needs assessment.

Four indicators of health status are considered. They have been selected for consideration for use within the HORSt based on being well accepted and documented performance measures of health outcomes and or health status. Measures were also considered because of practicality of collection for the case study, NSW. These are as follows:

1. Self-reported health surveys; including Patient reported outcomes (PROMS) and Patient Reported Experience Measures (PREMS;
2. Potentially Preventable Hospitalisations (PPHs);
3. Charlson Co-Morbidities; and
4. Standardised Mortality Ratios (SMRs).

Each of these is critiqued in detail in the following sub sections.

2.4.1 Self-reported health surveys

There is broad consensus in the international literature that self-reported health (SRH) surveys are a valid and reliable measure of health-related quality of life (HRQoL). International literature indicates that these instruments consistently demonstrate in cross sectional and longitudinal studies across populations of diverse socio economic backgrounds that self-appraisal of an individual's health is a powerful predictor of future morbidity and mortality (Appels et al. 1996; Borawski 1996; Chu 2017; Idler 1997; Idler 1991; Moreira 2018).

The attributes of SRH in the literature is particularly attractive to the HORSt as a performance measure of health outcomes. Whilst SRH represents one axiom of Bradshaw's social need (felt needs) it could be argued that as a generic performance measure of health outcomes per se that SRH is a product of interventions across the continuum of care.

The NSW Ministry of Health has conducted the NSW Adult Population Health Survey annually each year (since 1997) and the Child Population Health Survey (since 2001). This is an ongoing survey of the health of people in NSW using computer-assisted telephone interviewing (CATI). The main aims of the surveys are to provide detailed information on the health of adults and children in NSW and to support planning, implementation and evaluation of health services and programs in NSW (Population Health 2016).

For analysis, the survey sample was weighted to adjust for differences in the probabilities of selection among respondents. Post-stratification weights were used to reduce the effect of differing non-response rates among males and females and different age groups on the survey estimates. These weights were adjusted for differences between the age and sex structure of the survey sample. Population data based on Australian Bureau of Statistics estimates and population projections based on data from the NSW Department of Planning and Infrastructure have been used to calibrate weights to the population within each health LHN and the Australian Bureau of Statistics latest mid-year population estimates (excluding residents of institutions) for LHN (Population Health 2016).

Whilst the weights could inform the HORSt as a proxy of population health need, advice from the NSW Ministry of Health is that it is statistically problematic to determine accurate survey results for populations below the LHN level (Harrold 2017). Given wide ranging variation in social determinants across LHNs, lower level geographies of population areas within LHNs (discussed in Chapter Five) would be required for the HORSt. Unfortunately, this means this approach is not achievable for the study.

2.4.1.2 Patient reported outcome measures (PROMs) and Patient Reported Experience (PREMs)

Patient reported outcome measures (PROMs) and Patient Reported Experience Measures (PREMs) are measures of SRH. Where SRH surveys, such as the one used in NSW, report on the general health of the population, PROMs are instruments that that report on Patient Reported Outcomes. PROMs are closely aligned to the definition of health outcomes as they seek to enumerate the change in health outcome directly attributable to a health intervention, requiring a survey measure to be taken before and after a treatment. PREMs are instruments that report on the experience of the intervention and collected at a single point in time are used to report on aspects of quality and safety (Dawson et al. 2010; Kingsley & Patel 2017; Weldring & Smith 2013).

The HORSt requires a health outcomes performance measure that typifies what the overall health status is of the community which reflects the continuum of care. Sansoni (2016, pp. 26-7) indicates that recent developments in the collection of PROMs in Australia have sought to apply generic instruments that are compatible with assessment of models of care. These measures are compatible with considering the outcomes of interventions across the continuum of care. However, in Australia the establishment of clinical registries and protocols to collect the data and other PROMs initiatives is still in its infancy. Thompson et al. (2016, p. 3) describes the efforts to date as being *"fragmented and often isolated".* The implication for the HORSt is that for this study there is simply not enough data at this stage to make a realistic assessment for including PROMs as the measure of population health status.

PREMS by virtue of measuring experience, rather than outcomes, precludes their inclusion in the HORSt.

2.4.2 *PPHs as a proxy for population health status.*

As introduced in Chapter One (page 21), the literature has identified PPHs, evident within hospitalisation statistics as markers of health inequality (Falster et al. 2015; Falster et al. 2016). Duckett and Griffiths (2016a, p. 1), claim that where PPHs are persistent within geographical populations, to which they describe as "hot spots", they represent entrenched health inequalities that without intervention are most likely to endure.

A long standing theory surrounding PPHs was that their occurrence represented a lack of access to ambulatory care services, particularly primary care and preventative services (Ansari et al. 2006; Falster et al. 2016; Longman et al. 2011; Longman et al. 2015; Page et al. 2007; Victorian Health Information Surveillance System 2016). Duckett and Griffiths (2016a) contemporary work on hot spots is congruent with this theory, highlighting populations that are most in need of primary care investment interventions and recommend Primary Care Networks (PHNs) develop interventional strategies (pp. 37-42). The hypothesis surrounding PPHs and lack of access is that if appropriate access to primary services exists, these potentially avoidable hospitalisations would be minimised.

> *"In theory at least, if the condition is treated and/or managed appropriately in the community (through public health interventions, in general practice or with other community support) the patient is less likely to end up in hospital. Hospitalisations for ACSCs (PPHs[8]) are therefore considered to be potentially preventable"* (Duckett & Griffiths 2016a, p. 6).

However, contemporary Australian evidence refutes this hypothesis, finding that persons presenting to hospital with PPHs were found to not have limited access to primary care leading up to their PPH admission. In fact, these patients were found to be prolific uses of multiple elements of the health system prior to their admission. PPHs therefore are conditions associated with sicker patients (Falster et al. 2015; Falster et al. 2016). A logical extension of this finding is that PPHs may not be as avoidable as first thought through primary care interventions, although this cannot be confirmed without consideration as to the effectiveness of the health care received prior to admission and the health of the patient which is not evident in the contemporary literature.

[8] Duckett and Griffith use the term ACSCs.

Advocates in the literature for moving away from utilisation approaches to health needs have supported the development of morbidity measures to reflect need (Asthana & Gibson 2011; Asthana et al. 2004). PPHs certainly do reflect on the basis of the evidence presented a generic morbidity metric of health status.

Similar to the other data of health inequalities presented in Chapter One, PPHs are shown in the international and Australian literature to be strongly correlated with socioeconomic status with evidence showing a strong link between high rates of PPHs and socioeconomic disadvantage (Agabiti et al. 2009; Butler et al. 2013; Roos et al. 2005; Trachtenberg et al. 2014; Weeks et al. 2016). Consistent with this, high rates of PPHs are observed to be prolonged amongst socioeconomically disadvantaged communities (Duckett & Griffiths 2016a; Falster et al. 2015).

Tackling health inequities is an ongoing priority for Commonwealth and state governments (Australian Institute of Health and Welfare 2016a; Holland 2014; NSW Department of Health 2004) and reducing PPHs are part of that challenge. In Australia there are 22 categories of PPHs recognised within the National Health Care Agreement for action by Commonwealth and state governments, divided into three broad categories of Acute, Chronic and Vaccine Preventable (Australian Institute of Health and Welfare 2017b). These are listed in appendix 1.

In the context of NSW, figures 8 and 9 (pages 78 and 79) illustrate the health inequalities within populations via standardised rates of PPHs. Specifically, the example in Figure 9 shows the rate of PPHs for Acute, Chronic, Vaccine Preventable and All PPHs by NSW LHN in 2015/16 in number and by directly age gender standardised rate per 100,000 population. The age gender standardised rate for all categories of PPHs is also shown by quintiles of socioeconomic disadvantage in Figure 9 (Epidemiology and Evidence 2017).

Figure 8 2015-16 NSW PPHs, Acute, Chronic, Vaccine Preventable and Total by NSW LHN (LHD)

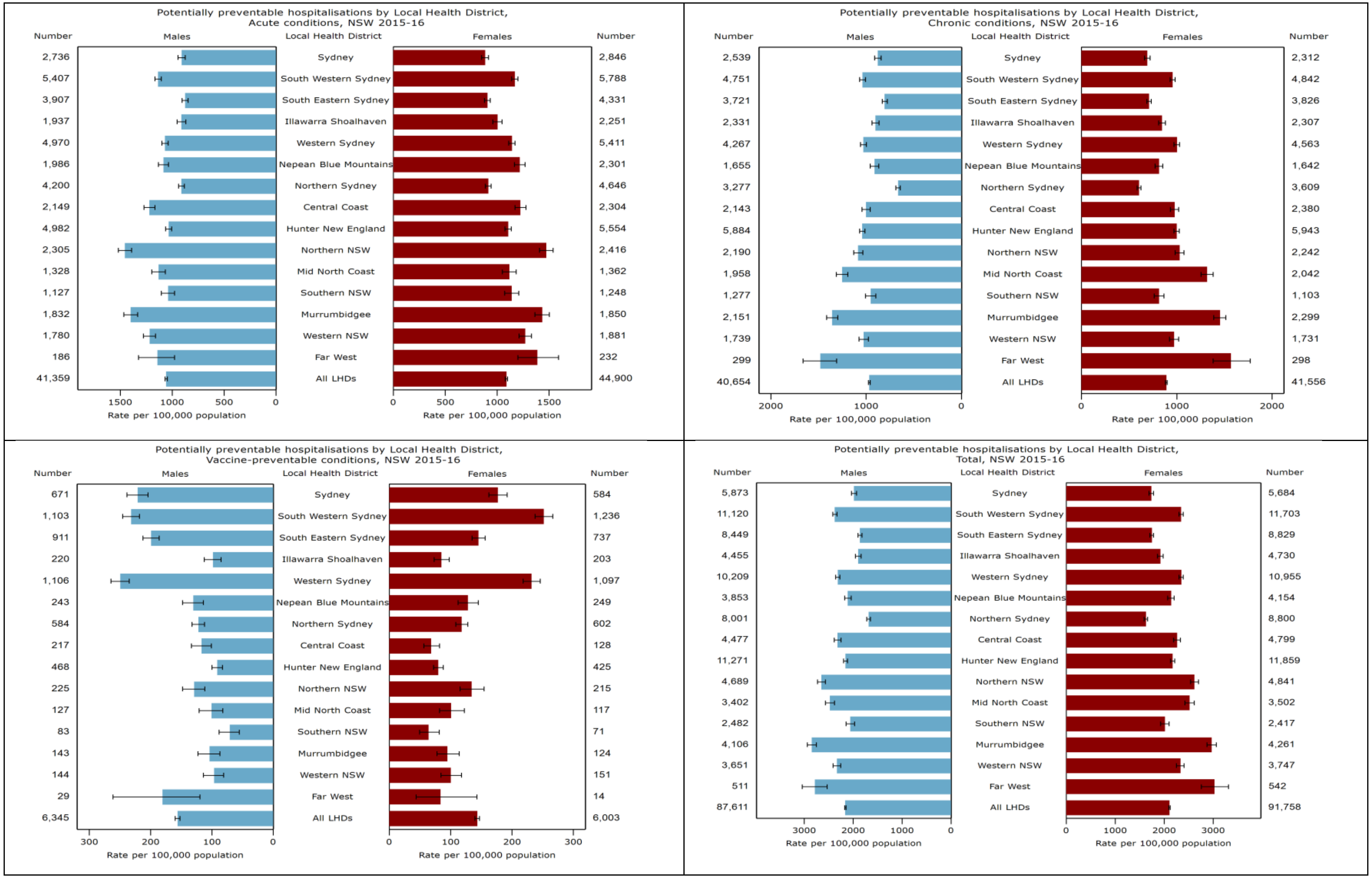

Figure 8 Source: (Epidemiology and Evidence 2017).

Figure 9 2015-16 NSW PPHs, Acute, Chronic, Vaccine Preventable and Total by ABS Socioeconomic disadvantage quintiles

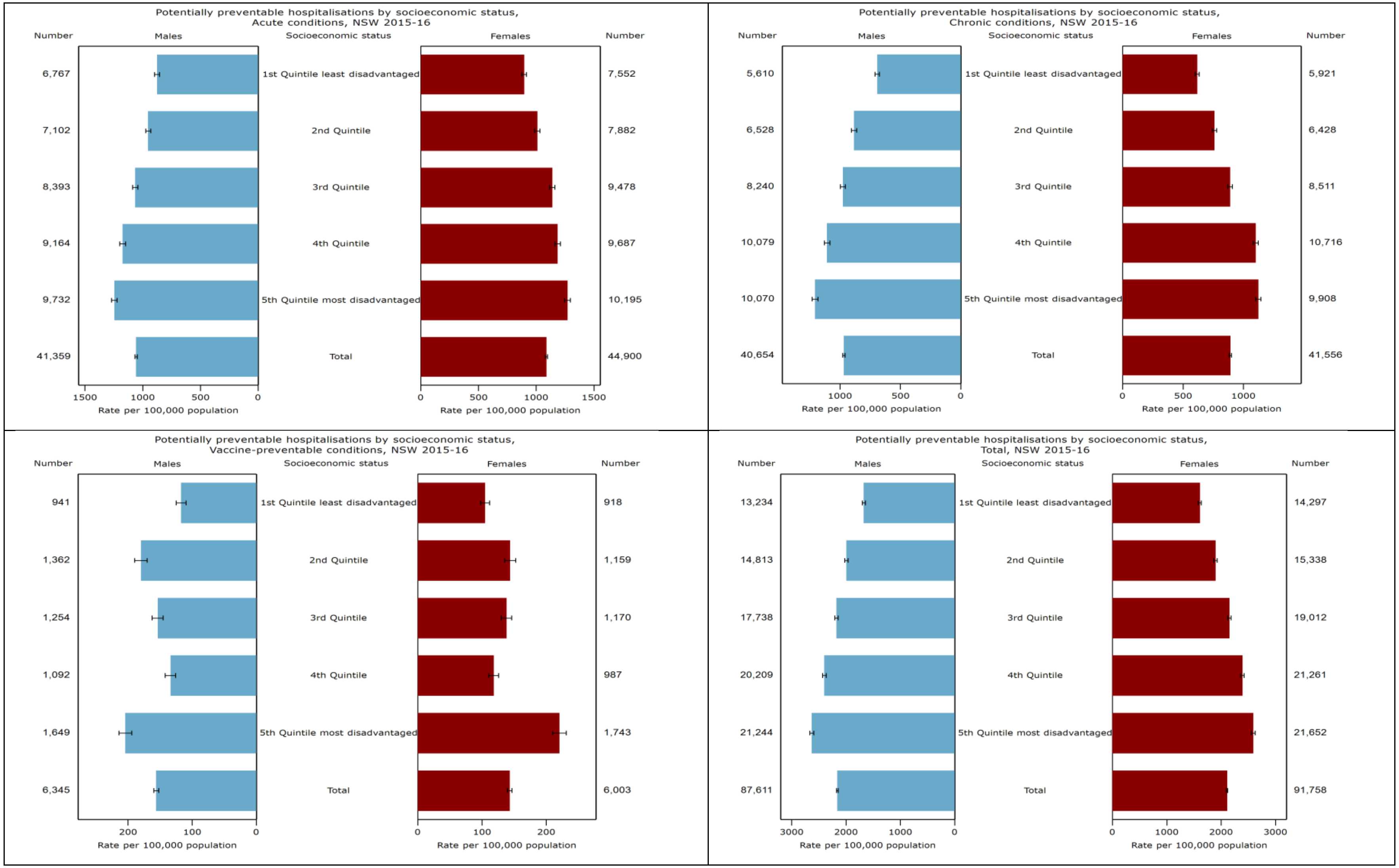

Figure 9 Source: (Epidemiology and Evidence 2017).

Figures 8 and 9 demonstrate the wide-ranging differences in the rate of PPHs across the NSW Health Districts and concur with the literature's findings that the most socioeconomically disadvantage quintiles within populations have much higher rates of age gender standardised PPHs than more socioeconomically advantaged quintiles.

In summary the literatures findings regarding PPHs is that they:

- are markers of health inequality (aligning with definitional criteria of health inequities presented in Chapter One);
- are representative of sicker patients;
- occur after the abundant consumption of resources across the continuum of care; and
- correlate with socioeconomic status, a social determinant of health outcomes.

Furthermore, PPHs represent three of the four categories of Bradshaw's framework of social needs i.e.

- PPHs reflected normative need; experts and evidence consider them health conditions that should be avoided. As such they are required to be reported and used as performance and quality indicators for state health systems (Australian Institute of Health and Welfare 2017b).
- PPHs reflect comparative need; to reiterate they are considered in comparison across small population areas as markers of inequality (Duckett & Griffiths 2016a).
- PPHs reflect expressed need. "A community or person who uses a lot of services is assumed to have high need" (Marosszeky et al. 2006, p. 4).

From this summary, it is reasonable to consider rates of age-standardised PPHs in small area populations as a proxy measure for poor population health status that can be used with the HORSt. Chapters Four and Five explores in more detail how PPHs can be utilised within the HORSt so as to represent a desirable level of population health outcomes.

2.4.3 Charlson comorbidity as a proxy measure for geographical population health status

Valderas et al. (2009, p. 357) describes comorbidity as being:

"*associated with worse health outcomes, more complex clinical management and increased health care costs"*.

Comorbidities are evident within Australian public hospital administrative data sets (Quan et al. 2011). A measure of comorbidities may serve as a measurable proxy of geographical population health status. Whilst there are many approaches for assessing comorbidities within administrative data sets, the Charlson index is the most widely applied and validated (de Groot et al. 2003; Hall 2006; Nadathur 2011).

Charlson's index was initially used to predict mortality based on 19 predefined comorbidities, that were weighted 1,2,3 or 6, with weighting based on ratio of hazard / severity, with the higher score indicating a higher burden of disease (Charlson et al. 1987). These are summarised in appendix 2. However, the use of the index has been varied over time, where it has been used to predict burden of disease, length of stay and health system costs (Charlson et al. 2014; Nadathur 2011). Latter studies have utilised a set of ICD-10 codes (International Statistical Classification of Diseases and Related Health Problems 10th Revision), which all Australian hospitals use, to identify hospital separations exhibiting comorbidities (Nadathur 2011).

Similar to PPHs, the literature indicates that comorbidity is inversely related to socioeconomic status (Chang et al. 2016). This makes their use as a proxy of geographical population health status attractive to the HORSt, whereby it would be expected that higher rates of observed comorbidity would exist where the social determinants of health care are poor. However, the use of a comorbidity index, poses a number of challenges for the proposed HORSt, including isolating hospital acquired comorbidities (a measure of poor quality) and age gender adjusting the comorbidities as there is a known correlation in the literature between age and comorbidity (Naessens et al. 2007; Yurkovich et al. 2015). Nonetheless, Charlson Co-morbidity rates from with state health hospital data collections can be utilised as a proxy measure of small area populations' health status. Methodology and data feasibility for including them within the HORSt in this context is explored in more detail in Chapters Four and Five.

2.4.4 Standardised Mortality Ratios (SMRs)

As outlined in the section on population needs-based funding models (page 52), the use of SMRs in these instruments is well established. Typically, premature mortality is used for SMRs below an age limit. The first version of the RAWP in England used this as sole indicator of health need and the many other models, including the former NSW RDF have at some stage used this measure (see Table 6 page 62).

An important issue that becomes apparent from the literature is that there is conjecture as to whether or not mortality actually represents need and if mortality is a need indicator itself, or as in the examples provided in Table 6, an indicator that explains utilisation where utilisation is the proxy of need. The original English RAWP, Italian and Scottish models use mortality as needs adjuster with no reference to utilisation, whereas the former RDF formally made a link whereby utilisation representing morbidity would be associated with higher rates of mortality (Bedard et al. 2000; Rice & Smith 1999). The RAWP model evolution from the SMR as the sole indicator of need to a model that reflected utilisation was because it was viewed that the SMR did not reflect the demand for health care associated with chronic disease and social deprivation (Asthana et al. 2004; Barr et al. 2014; Carr-Hill & Sheldon 1992).

Notwithstanding the literatures views on the use of mortality as a need indicator, mortality ratios are a population health outcome measure. Sansoni (2016, p. 20) highlights that there are some important considerations for their use being:
"they are not particularly responsive to the change in delivery of health care, as for many conditions it may take some years for the reduction in mortality, or increase in years of survival, to become apparent".

Contextualised to operationalising the HORSt as resource distribution tool and funding enabler to improve health outcomes and health inequities, the use of a premature SMR to do so is problematic. First there are strong arguments in the literature that the measure does reflect needs and social determinants of health outcomes. Second, premature SMRs may not be the best measure for recurrent funding distribution or as an enabler for improving health outcomes that involve improving morbidity outcomes. In light of these arguments and those in this literature review that champion an alternative method to utilisation of approximating need, the HORSt will not consider the SMR as the health outcomes proxy measure of need. Although given the widespread use of the SMR as a predictor of utilisation, the SMR will be assessed for its predictive strength of the health need variable that is ultimately selected.

Summary of key findings section 2.4 - Proxy measures of health outcomes that can be used as measures of population health need for use in the HORSt:

-Population health status performance measures can be utilised as a proxy for population health outcomes.

-Morbidity measures such as rates of PPHs and Charlson Comorbidities could be used in place of utilisation as measures of population health needs. Higher rates would indicate higher rates of illness.

-Higher rates of PPHs and Charlson-Comorbidities correlate with poorer social determinants of health and vice versa.

-Rates of PPHs are well established health outcomes performance measures, utilised by the Australian Governments and states.

-Rates of PPHs satisfy three of four measures social need defined by Bradshaw.

2.5 USING BENCHMARKED OUTCOMES FOR ENABLING EQUITY IN AUSTRALIAN PUBLIC SCHOOL EDUCATION – THE GONSKI SCHOOL RESOURCING STANDARD

Many of these issues identified in the Australian health care system are equally relevant to the funding provisions of other Australian state government responsibilities. There are strong parallels between publicly provided health care and publicly provided school education in Australia. Both are constitutionally prescribed under Australia's federalism as a state government responsibility and both are a mix of public and private providers, whereby private providers are publicly subsidised by the taxpayer (Parliament of Australia 2015). Furthermore, many of the social determinants of health that give rise to health inequities and poorer health outcomes are also observed to cause barriers to educational outcomes (Commission on Social Determinants of Health 2008b, p. 57; Marmot 2005, p. 1100). Given this, in developing the HORSt, it is appropriate to consider funding models that have been developed for the equitable distribution of public funding for schools in Australia. The following section discuss funding models developed for public funding distributions for schools' education in the Australian context and critique these models for applicability to developing the HORSt.

2.5.1 Gonski's School Resourcing Standard

Given the similar governance and funding arrangements and equity and efficiency issues in school education in Australia to that of the public health system, unsurprisingly similar challenges of public funding resource distribution occur. In response to this in 2010 the Rudd Labor Government established a review of school funding chaired by David Gonksi (Gonski et al. 2011, p. xi). Analogously to health where Medicare benefits (taxpayer funds) are observed to be disproportionately used across locations to fund private doctors (Bickerdyke et al. 2002, p. 212; Eckermann & Sheridan 2016, p. 512), Gonksi observed that school funding in Australia is also disproportionate with some private schools getting more funding from taxpayers than needed (Gonski et al. 2011, p. xvi). In terms of inequities of educational outcomes Gonski's review of funding for schools found that:

> *"The key dimensions of disadvantage that are having a significant impact on educational performance in Australia are socioeconomic status, indigeneity, English language proficiency, disability and school remoteness*" (Gonski et al. 2011, p. 122).

Whilst Gonksi et.al made forty-one recommendations, a key aspect of these is the development of a School Resourcing Standard (SRS). This outlines a mechanism to redistribute resources to address social determinants that act as barriers to academic achievement (Gonski et al. 2011, p. 225;

Parliament of Australia 2015). The Gonksi SRS has at its starting point, educational outcomes using the National Assessment Program—Literacy and Numeracy (NAPLAN) assessment results (Gonski et al. 2011, p. 68).

The Gonski et al (2011) SRS approach is only concerned with recurrent funding, not capital (p. 162). The SRS in Figure 10 shows the basic operation of the SRS. This involves establishing references schools where NAPLAN results are considered to be at an acceptable level and where the social determinants to educational outcomes for these schools and their students are favourable and not considered barriers to academic achievement. This is analogous to a benchmark. Regression techniques are then used with all sources of school funding (public and private) to benchmark a reference cost per student for these outcomes (pp. 255-6). Further regression analysis then prescribes loadings to be paid to schools where NAPLAN outcomes are below the reference level and the social determinants of educational outcomes are unfavourable (low socio-economic status, indigeneity, low level of English, disability and rural remote location). These loadings are paid on top of the reference level (pp. 257-9). These loadings constitute vertical equity adjustments; reflecting that greater resources should be applied to those who have a greater capacity to benefit, a greater need.

Figure 10 The Gonksi SRS

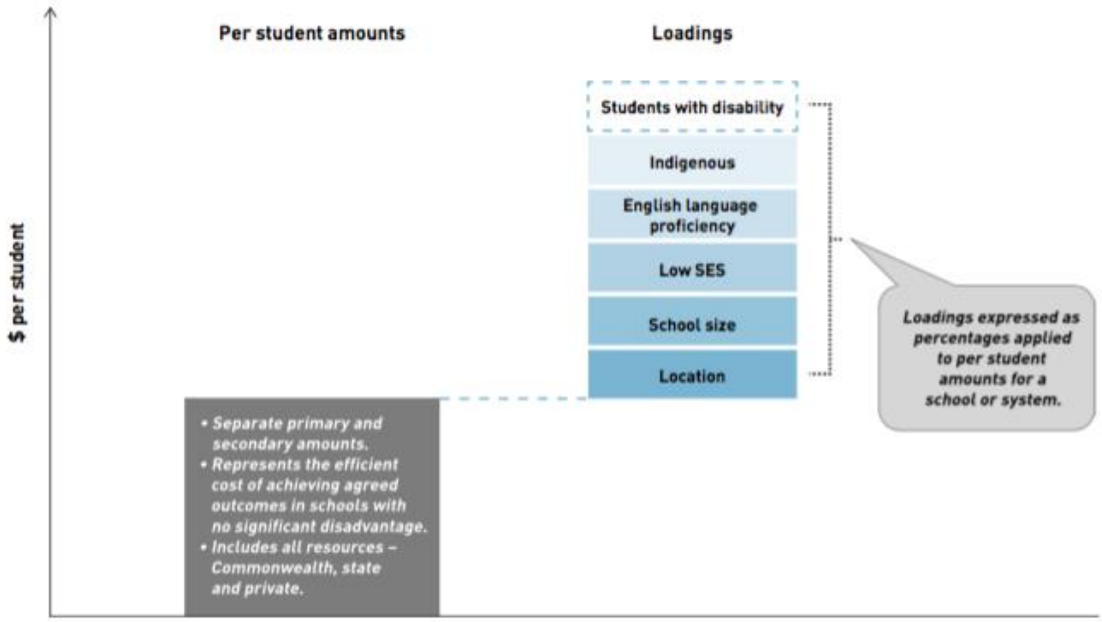

Figure 10 above is Figure 50 in the Gonski Review of School Funding (Gonski et al. 2011, p. 154). The box on the left-hand side of Figure 10 reflects a benchmark level of resource per student from public and private resources to achieve a benchmarked level of educational outcomes that are desirable.

Where social determinants are observed in geographical areas to be a barrier to achieving the benchmarked outcomes, schools in these geographical areas financial receiving loadings (right-hand Figure 10) on top of the benchmarked resources identified.

Making outcomes the focus is an attractive alternative approach to state health funding models that have heavily focused on efficiency of funding services rather than outcomes. i.e.
"The Gonski report provides a completely different lens through which to view, measure and fund service systems. It is a view that is almost completely counter to the way governments and policy makers currently approach health systems. The most fundamental difference is that Gonski begins with a focus on student achievement of real education outcomes. In health, we are still stuck trying to look at throughputs and costs – an almost entirely provider focused approach where actual health outcomes are not even measured. We are trying to run the system more efficiently, but take no real account of health outcomes" (Bennett 2012).

The principles of Gonksi for school education has been very popular with the public in Australia (Aston 2016). However, criticisms do exist. These are: the additional funding for schools recommended has been argued to be unaffordable; and the ability of schools receiving extra resources to spend the money efficiently has been questioned (Jensen 2013; Slater 2016). However, using a Gonski approach to a state health resourcing tool like the HORSt, it is not envisaged that these criticisms would be sustained, given that the intent of the HORSt is to act as the first step in the funding model, utilising ABF as the second to promote technical efficiency.

Given the similar challenges of resource distribution and similar social determinants that give rise to inequities in school education and health outcomes, the use of the Gonski SRS, with its benchmarked productivity approach of assessing a wide range of funding inputs and social determinants affects upon desirable and measurable outputs, is an attractive conceptual and methodological approach to developing the HORSt as a funding model that can promote allocative efficiency and equity of state health distributions to LHNs. Setting a level of benchmarked outcomes for the whole population is congruent with the social justice views of Rawls and Daniel discussed in section 2.1 (page 37) whereby it is just that society affords each member the opportunity to have a decent minimum level of health.

Summary of key findings section 2.5

Using benchmarked outcomes for enabling equity in Australian public-school education – The Gonski school resourcing standard

-State public school funding faces similar governance and funding challenges and resourcing decisions as that of the state public health sector.

-Gonski school education “school resourcing standard” uses an outcomes-based approach to assess students’ needs.

- School resourcing standard (SRS) - applies a benchmark to outcomes

- SRS utilises a broad approach to considering funding inputs to be included in the determination of the productivity of outcomes and the resourcing share of funding required by the state government

- Recommends school resourcing shares of funding be based on social determinants that affect achievement of the benchmarked outcomes.

Populations that are allocative efficient in the production of desirable health outcomes can serve as benchmark. Resource distribution can be informed by redistributing funding to population’s that have poor allocative efficiency compared to the benchmark, due to poor social determinants of health that affect allocative efficiency. Doing so represents a funding enabler on the basis of capacity to benefit and is congruent to social justice theories by Rawls and Daniels.

2.6 CONCEPTUAL FRAMEWORK

The Conceptual Framework for this study is presented in Figure 11 (page 88). This shows the connections between the literature’s findings, the study aims and research questions and the methodological development and process that will be required to satisfy these.

Figure 11 Conceptual Framework for the study

Literature – Findings / Gaps / Opportunities	**Aims**	**Research Questions**	**Methodology development / processes to address research questions**
Resource distribution to enable improvement in equity and outcomes justified by theories of social justice Need in health care best expressed in terms of capacity to benefit (vertical equity) rather than utilisation (horizontal equity). Efficiency (all types) can be improved by moving away from siloed approaches to funding and considering continuum of care Cost and ABF funding models do not advance equity or improved outcomes or allocative efficiency Population needs-based models implicitly enable equity and allocative efficiency yet can be improved to more transparently do so via measuring allocative efficiency of health outcomes. Doing so involves establishing benchmark and considering resource inputs involved in the production of health outcomes across the continuum of care – not just from within the state health silo. Doing so ends a reliance of need being approximated by utilisation and is congruent with need expressed as capacity to benefit. Population measures of health status, using measures of morbidity (PPHs and Charlson rates) can be used as a health outcomes proxy. Gonski SRS – demonstrates in school education that a benchmark approach – placing outcomes at centre of the model and then considering social determinants that affect the benchmark to inform needs-based funding is viable.	**AIM 1**- Develop the HORSt as a parsimonious, measurable and consistent benchmark of desirable health outcomes for states' LHNs' populations, relative to funding inputs across the continuum of care, to promote allocative efficiency and equity across populations.	What measures / data of health status can best represent an acceptable level of desirable health outcomes for populations that can inform a benchmark? What health service funding inputs should be included to represent the continuum of care? What methodology should be applied to derive the benchmark?	Identify data sources to best represent benchmarked outcomes (PPHs or Charlson rates) as per literature review. Identify / justify a benchmarking methodology. The benchmark should be a measure of the allocative efficiency of the outcomes variable and in doing so incorporate variables that represent the resourcing inputs across the continuum of care.
	AIM 2: Identify and incorporate measures of local geographical population health needs that can be used in resource allocation decisions.	What are appropriate measures of population need that could be applied to support the HORSt?	Identify / justify variables that best predict / affect the populations' ability to achieve allocative efficiency of desired health outcomes Identify / justify a predictive methodology
	AIM 3: Identify the share and quantum of taxpayer resources provided by the state to geographical populations to maximise equity of health funding across the continuum of care to act as an enabler to improve equity of health outcomes.	What share of funding is required for each geographical population to adjust for population health needs to maximise equity of health funding across the continuum of care? What quantum of funding is required to be adjusted by the state from the existing pool of resources used by each?	Developing health need indices from the need variables that can act as population weights to inform resource distribution. Identifying and justifying the pool of funds across the continuum of care that the need indices should be applied too. Calculating the state share of needs-based / needs weighted funding for each LHN.

2.7 CHAPTER SUMMARY - GAPS, ISSUES, OPPORTUNITIES, WEAKNESSES IDENTIFIED IN PREVIOUS RESEARCH

The literature critiqued in this chapter has illustrated several key issues and consistent findings that are pertinent to the development of the HORSt and the advancement of improving the equitable distribution of state health funding amongst LHNs, whilst supporting the efficiency goals of ABF. Gaps, issues, opportunities and weaknesses identified in the literature are presented in summary and examined in the subsections below. As is apparent findings and implications from each of the literature reviews sections are interrelated and somewhat overlap. For brevity this summary synthesises these issues.

Vertical equity and need

From a social justice perspective, the literature demonstrates that Daniel's extension of Rawlsian views of just resource distribution for affording opportunities to improve equity in health outcomes are aligned to needs defined by capacity to benefit, which is how the literature describes the most appropriate way to consider need. However, the practical approach to doing so in Australia under Medicare principles is more aligned to the promotion of equality via equal access.

Funding models and tools employed at the state level in Australia are equally lacking in addressing population needs in terms of capacity to benefit which is consistent with the international literature's findings that the majority of funding models that have sought to advance population need have done so via expressing need as health system use. This represents a gap in the literature where vertical equity approaches within funding instruments to tackling just population needs-based resource distribution have been underutilised. Hence there is scope to represent need in terms of capacity to benefit in the context of vertical equity within the HORSt.

Efficiency and the continuum of care

Segments of the international literature that purport a trade-off between equity and efficiency are unhelpful for policy makers, whereby the trade-off argument may convey views that population needs-based tools promoting equity may be doing so at the opportunity cost of compromising efficiency. The literature review demonstrated that the trade-off argument needs qualification whereby the policy pursuit of equity and efficiency is a deliberative complementary process and that both pursuits can be complementary.

The structural funding and governance arrangements also can affect the pursuit of equity, where policy is set within demarcated areas to produce outputs. The lack of attention for resource distribution funding instruments aligned to payment for the improvement of health outcomes represents a significant gap in the literature. Developing funding models that consider the productive contributions of health service outputs to health outcomes across the continuum of care is essential for improving allocative efficiency.

Gonski recognised that school outputs were a function of social determinants of education and the productivity of funding inputs from all sources of school funding (public and private). Similarly, it is logical to represent the continuum of care in the HORSt in terms of social determinants of health and the productivity of funding inputs from as many measurable and reliable sources across the continuum of care of the multi-layer mixed public / private health system. Gonski recognised the importance of this functional relationship in the school resourcing standard, via approaching the needs-based problem in the context of productivity via a benchmark. The HORSt seeks to do the same.

Funding models – Equity and Efficiency

ABF can promote technical efficiency. However, current cost based and ABF models cannot advance equity. Cost models promote the status quo and ABF can, if left unchecked, overproduce.

Population needs-based funding act as enablers to implicitly improve allocative efficiency of resource distribution and improve health outcomes. However, need is almost exclusively expressed by utilisation, expressed demand and resource allocation is guided by weighting population shares according to variables that predict utilisation. These models do not explicitly improve allocative efficiency and none of the literature seeks to measure allocative efficiency.

Opportunities exist for the HORSt to consider measuring allocative efficiency. This will require considering the productive inputs across the continuum of care to produce a desirable level of health outcomes. Developing a benchmark for the HORSt as per the Gonski SRS is a sensible and just approach. Doing so will involve considering a proxy measure for the health status of the population as proxy of health outcomes. Resource distribution population shares can be weighted for variables found to affect the allocative efficiency of achieving the benchmark.

Variables to approximate health system need via population health status

The use of PPHs or Charlson Co-Morbidities from within state health inpatient statistics affords the use of a health outcomes approach. Both metrics are shown in the literature to represent sicker patients and within populations are makers of poor health status.

Benchmarking outcomes – Gonksi experience

The similar issues that have arisen in publicly subsidised education in Australia, regarding fairness of resource distribution and the contemporary approach by Gonski, demonstrates an opportunity for the development of a HORSt as a resource distribution tool for health care with a focus on health outcomes. Doing so would substantially differentiate the HORSt to previous population needs-based models in health that have approximated need by health system access (use). Doing so would also promote vertical equity and define need by capacity to benefit.

Given the public support for the Gonski SRS which has shifted the focus on educational outcomes, the HORSt designed upon similar conceptual and methodological underpinnings would make publicly subsidised health funding transparent across populations and shift the focus from outputs to health outcomes.

CHAPTER THREE – REVIEW OF GOVERNANCE AND FUNDING ARRANGEMENTS OF TAXPAYER PROVIDED AND SUBSIDISED HEALTH CARE IN AUSTRALIA

3.0 INTRODUCTION

Chapter One provided an overview to funding and governance arrangements of the mixed public / private Australian Health Care system. This section provides a critique of the specific funding and governance arrangements that embody the Australian health care system, examining the origins and operation of the mixed public private system in the context of public funding and public subsidisation from the Australian and state governments. Contextualised to the literature review and conceptual framework for developing the HORSt in Chapter Two, the advancement of equity and efficiency within each layer of publicly provided and subsidised health care is examined, along with relevant legislative issues that bound the Australian federal system of government. Characteristics of the funding and governance arrangements that are relevant to the development of the HORSt at the state level across the continuum of care are identified and appraised for their inclusion in the model's methodology and for feasibility as data sources. Discussion is organised under the following sections that consider taxpayer funding distributions between:

- Commonwealth and states;
- Commonwealth and private providers via the MBS;
- Commonwealth and private insurers;
- Commonwealth / states and clients of the NDIS; and
- Commonwealth and private individuals for the PBS.

Out-of-pocket costs paid by individuals are also examined.

3.1 GOVERNANCE AND FUNDING DISTRIBUTIONS FROM COMMONWEALTH TO STATES

The Australian Constitution came into effect in 1901 and established Commonwealth and state powers (Parliament Education Office 2015a, p. 4). Prior to World War Two (WWII), both Commonwealth and states collected income taxes. However, in 1942 due to the financial requirements of the war effort, the Commonwealth sought to become the sole collector of income tax, compensating states for their loss of tax revenue in the form of conditional funding grants. The Commonwealth legislation sought was challenged in the High Court by four states but found to be constitutionally sound in what was called the "Uniform Tax case 1942" (Parliament Education Office

2015b; The Constitutional Centre of Western Australia 2015). Whilst employed as a wartime measure for the duration of the war plus one year, this arrangement was sought by the Chifley government in 1946 to continue indefinitely and despite several high court challenges since this arrangement remains (Boxall & Gillespie 2013, p. 25; Burton et al. 2002, p. 15).

The Commonwealth's initial health responsibilities were limited to quarantine issues (Eagar et al. 2001, p. 26). However, an amendment to section 51 of the Australian Constitution in 1946 which allowed the Commonwealth to make financial provisions for social services, including health benefits, was achieved through referendum. Specifically, the amendment sought:

> *"The provision of maternity allowances, widows' pensions, child endowment, unemployment, pharmaceutical, sickness and hospital benefits, medical and dental services (but not so as to authorize any form of civil conscription), benefits to students and family allowances"* (Australian Senate 1946).

The provision of public hospital services however, still resided thereafter with state governments with no explicit Commonwealth power to administer public hospitals or to make laws for public hospitals (Scully 2009).

The ceding of income taxes in 1942 solely to the Commonwealth is considered to be a watershed moment for vertical fiscal imbalance (VFI) in Australia (Burton et al. 2002). VFI occurs whereby the Commonwealth government's ability to raise revenues exceeds its spending responsibilities and the state governments have insufficient revenues from their own sources to finance spending responsibilities (Department of Finance 2014). Mathews and Jay (1972, p. 191) described the impacts of the imbalance on the states in both fiscal and policy terms;

> *"not only had the Commonwealth government, with its vast wartime powers, become used to taking unilateral action with respect to decisions affecting the prosecution and financing of the war, the control of the war-time economy and the arrangements for post-war reconstruction; its assumption of uniform income tax powers had given it the fiscal supremacy to pursue the centripetal policies."*

This new power and fiscal might wielded by the Commonwealth government had the direct result of states becoming more dependent upon Commonwealth funding for all areas of state responsibilities, including the provision of public hospital services. The Commonwealth's desire to influence state policy, despite having no constitutional power to administer public hospitals, has increased with the imbalance (Crowe & Stephenson 2014; Duckett 2000, p. 95).

The key instrument of Commonwealth influence in state health funding policy is the funding agreements with the states. Known previously as the Medicare agreement, the Australian Health Care Agreement (AHCA) and more recently as the National Health Reform Agreement (NHRA), these agreements establish principles, standards and expectations of access, service and volume that states have to follow (Parliament of Australia 2014; Paterson 2002, p. 313). The agreements ensure that states uphold Medicare principles, being:

- "Medicare eligible persons are to be given the choice to receive, free of charge as public patients, health and emergency services of a kind or kinds that are currently, or were historically provided by hospitals;
- access to such services by public patients free of charge is to be on the basis of clinical need and within a clinically appropriate period; and
- arrangements are to be in place to ensure equitable access to such services for all eligible persons, regardless of their geographic location"

(Council of Australian Governments 2011, p. 5).

The Medicare principles are statements of equity to be adhered to by the states. As introduced in the equity section of the literature review, these principles broadly align with the concept of horizontal equity, given the strong focus on equality of access. However, the universality of Medicare in the context of clinical need is also aligned to vertical equity, as patients who have more severe illnesses are not denied access to greater resources, they require than those with lesser clinical need. Consistent with Medicare's strong focus on equity, Duckett (2000, p. 224) has described the Australian health care system's "quest for equity" as being a pivotal issue since the 1960's. He contends that equity of access has been the principal driver of reforms that has ultimately culminated in the contemporary Medicare system, which is;

> *"designed to ensure that all Australians have equal access to care in public systems"* (p. xxi).

Up until 2012, the mechanism of distributing what constitutes an equitable share of Commonwealth funding to the states to address the VFI occurs via funding transfer agreements called Specific Purpose Payments (SPPs). These cover: health; schools; housing; indigenous affairs; disability services; skills; and training development (Commonwealth Grants Commission 2015). Funding transfers for SPPs are subject to negotiation between the Commonwealth and states, (including the health care agreements as discussed). The quantity of the funds supplied, which are distributed amongst the states, are subject to recommendations by the Commonwealth Grants Commission (CGC). The CGC considers the population needs of each state relative to the average need of the population across all states. Population need is largely assessed on per capita criteria (Commonwealth Grants Commission 2015).

Negotiations between Commonwealth and states for the health funding agreements are often prolonged, political and at times acrimonious. Common sources of conflict surround the size of the Commonwealth's financial contribution to the states and attempts by both parties to actively "cost shift" patients and their costs between privately provided taxpayer subsidised Medicare services and that of public hospitals and vice versa (Duckett 2004a, p. 2; Maiden 2010; Milne 2010). Cost-shifting has been described as a central cause of buck passing between jurisdictions, with the buck passing described as "the blame game" (Standing Committee on Health and Ageing 2006, p. 40). Severe penalties in terms of withholding hundreds of millions of dollars of Commonwealth funding can and have been applied to state breaches of the Medicare principles underpinning these agreements (Auditor-General 2007, p. 49; Parliament of Australia 1998).

Improved health outcomes are not the result of a siloed differentiated production line of health care from either Commonwealth or state responsibilities, however as identified in the literature review are affected by patient's access and interaction with the continuum of care. Therefore, it would be naïve to consider that all forms of cost shifting are undesirable. Cost shifting, whilst being expedient to the bottom line of either state or Commonwealth budgets, can actually benefit improved patient outcomes and the overall efficiency of taxpayer funding considered in totality rather than in terms of demarcated Commonwealth and state budgets. The continuum of care is logically independent of issues of who pays for what, but nonetheless impacted upon by the governance of payment arrangements.

In the Australian context, within the continuum of care, primary care services delivered privately by general practitioners (GPs) and subsidised by the Commonwealth government are more cost effective than allowing for illness to progress to where it requires hospital interventions. They are also more cost effective than the use of a hospital emergency department in lieu of access to a GP (Eckermann 2014a). In response to this, state health systems have an incentive to work collaboratively with other levels of the health system outside of their control. State health systems seek to engage the other parts of the continuum by strategies of "integrated care" (Kodner & Spreeuwenberg 2002, p. 1).

Integrated care refers to:

> *"the provision of seamless, effective and efficient care that reflects the whole of a person's health needs, from prevention through to end of life, across physical and mental health, in partnership with the individual, their carers and family and across public/private and Commonwealth/ State boundaries"* (Office of the Secretary 2015, p. 15).

NSW Health for example, has made concentrated efforts in recent years to invest in hospital avoidance and integrated care strategies, culminating with its 2015 State Health Plan goal of "keeping people healthy and out of hospital" (Office of the Secretary 2015, p. 8). However, doing so could also be branded as cost shifting by the Commonwealth, if the benefits of investing in the continuum of care are ignored.

From 2012, the Rudd Labor Government replaced the CGC health funding distribution to states by using ABF. All states and territories were required to be part of a NHRA whereby the Commonwealth's contribution to states was linked to state public hospital activity based on an efficient price for hospital services determined by the Independent Hospital Pricing Authority (IHPA) (Council of Australian Governments 2011). ABF's key expected improvements were the coordination of a nationally transparent methodology for paying for public hospital outputs and the promoting and incentivising of technical efficiency through paying for outputs at a benchmarked price (Health Policy Solutions et al. 2011). This provided the Commonwealth with an incentive to encourage states to shift patients into more cost efficient primary care and was sought therefore as a solution to ending the blame game (Duckett 2013, 2014).

Eagar et al (2011) suggested that the ending of the blame game through National Health reform strategies encourages an environment of dynamic efficiency whereby there are opportunities for the innovation and integration of successful programs that cross the continuum of care. From 2017 onwards however, the Abbott / Turnbull Liberal Government dropped the link to activity for state hospital funding and essentially replaced it with similar principles of the previous CGC model. Funding from Commonwealth to states provides revenues that support the state's budgets which include a provision for the state health budget (Parliament of Australia 2014).

Implementing the HORSt as a tool to guide state distributions to LHNs does require being compatible with the Medicare principles governing Commonwealth funding to states. Population needs-based funding models previously used in NSW and QLD (discussed in section 2.3 page 52) spanned some 22 years and 4 years respectively (Ho 2001; Slater 2014). During this time, they coexisted amicably with the Medicare principles of the respective AHCAs without incurring any breach of the agreements and it follows that the HORSt acting as a similar mechanism does not require any regulatory reform between Commonwealth and states.

3.2 TAXPAYER SUBSIDIES FROM COMMONWEALTH TO PRIVATE DOCTORS

Private health care in Australia is dominated by General Practitioners (GPs) and Specialists. Whilst publicly subsidised by the taxpayer through Medicare, the distribution of these private services, with the exception of incentivising doctors to work in locations of need such as the Rural Health Workforce Strategy (Department of Health 2013), has not been subject to a distributive equity mechanism. The defining rationale for why this is so, relates back to the 1946 social services referendum.

Apart from providing the Commonwealth with new powers to provide health benefits, the 1946 amendment to section 51 of the constitution was also a significant step towards enshrining the mixed public / private Australian health care system, as it guaranteed (save for future changes to the constitution) the freedom of private practice of Australian doctors. Sought by lobbying from the British Medical Association (BMA)[9], the anti-conscription clause that was included in the amendment allowed for the Commonwealth to provide:

> *"medical and dental services (but not so as to authorize any form of civil conscription)"* (Australian Senate 1946);

was designed to;

> *"avoid doctors being conscripted into government service"* (Browning 2000).

The high court has confirmed the purpose of the anti-conscription clause and the limits it places on the ability of the Commonwealth government to reform the public / private mixed system in the future. i.e. In Wong v Commonwealth the high court found that in reference to section 51 xxiii of the constitution that:

"A civil conscription guarantee should be construed widely and that it would invalidate federal laws requiring providers of medical and dental services (either expressly or by practical compulsion) to work for the federal government or any specified State, agency or private industrial employer. ***This***

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[9] The Australian Medical Association (AMA) was formed from merged branches of the BMA in 1962 (Australian Medical Association 2016).

decision is likely to restrict the capacity of any future federal government to restructure the Australian health care system, e.g. by implementing recommendations from the National Health and Hospitals Reform Commission for either federal government or private corporate control of presently State-run public hospitals" (Faunce 2009, p. 196, emphasis added).

As a result of this seminal legislative protection from forced employment, private practitioners choosing their location and establishing their own fee structure can create financial and geographical barriers to people accessing primary and secondary care (McRae & van Gool 2017). The power of the medical establishment in avoiding controlling government influences in Australia is significant and a key challenge to reform and the advancement of a more equitably distributed health system (Boxall & Gillespie 2013; Palmer & Short 2014).

Despite the significant power of the medical establishment in Australia, according to Boxall and Gillespie (2013, pp. 10-1), the medical workforce is not always aligned to the self-interested political directions taken by the medical establishment. Furthermore, there is a long history in Australia of beneficent doctors actively price discriminating advantageously for patients of limited financial means (Johar 2012).

The payment system to private practitioners via taxpayer subsidisation (Medicare) is also an important consideration of the advancement of equity and efficiency. Medicare, as a fee-for-service model to pay for services of private practitioners (Department of Human Services 2015), is an output-basedmodel like ABF. Therefore, as discussed, there are incentives to over produce. However, unlike an ABF model at the state level with the state budget acting as the ultimate resource constraint above it and the states allowed to ration services under the second Medicare principle on the basis of clinical need, the Medicare payment system for private practitioners is somewhat open-ended with physicians acting as gatekeepers to the volume of services delivered (Webber 2012).

The information asymmetry between clinicians and patients, where clinicians are imperfect agents to their patients can also support the over production and commonly this situation in the literature is referred to as Supplier Induced Demand (Bickerdyke et al. 2002, p. 12; Eckermann & Sheridan 2016, p. 512; Mcguire et al. 1994, p. 36). As such, the fee-for-service model does not encourage allocative efficiency and combined with the freedom of practice in locations that suit the doctor, the model does not advance equity. Furthermore, as an episodic funding model, it is not designed to support improvements in integrated care (Boxall & Gillespie 2013, p. 175).

Medicare pays private practitioners contributions towards each service via the MBS. For non-hospital services, Medicare covers services for doctors, specialists, optometrists and in specific circumstances, dentists and other allied health practitioners on a fee-for-service basis up to a schedule fee set out by the MBS. Beyond the schedule fee the patient is liable for out-of-pocket charges set by the practitioner (Department of Human Services 2015).

If the patient elects to be a private patient in a public or private hospital, Medicare covers 75% of the MBS fee for services and procedures. Medical practitioner charges beyond this are the responsibility of the patient, as are hospital accommodation and items such as theatre fees and medicines. PHI can reimburse the remaining 25% of the schedule fee and the accommodation and medical costs (Department of Human Services 2015).

The MBS payments for each consultation, as the universal insurance component within private doctors' fees acts to some degree as a transparent price floor (Johar et al. 2016, p. 528). Further, it can encourage price competition amongst practitioners who charge fees and amongst those that bulk bill (charge no out-of-pocket costs). Beneficent and entrepreneurial practitioners, price discriminate amongst patients, bulk billing (not charging out-of-pocket costs) to those with limited means, charging out-of-pocket costs to patients who are more socioeconomically advantaged (Johar 2012, p. 597; Johar et al. 2016, pp. 530-2).

Whilst medical beneficence by private practitioners to needy people could be seen to advance equity, the reliance upon private doctors in the marketplace to always do so is not guaranteed. Furthermore, recent studies indicate that the out-of-pocket costs that Australians face are rising (Scott 2016). Where ambulatory patients cannot afford fees and are not able to access bulk billing, the alternative is using the public hospital system typically via emergency departments (Eckermann 2014a). Using hospital for the treatment of illness that could otherwise be treated in primary care is allocatively inefficient, ultimately costing the taxpayer more. In terms of equity, Eckermann et al. (2016, p. 7) find that supplier induced demand is likely to occur as a result of a reduction in bulk billing .i.e.

> *"The under-servicing of 'at need' populations with reduction of bulk billing rates also leads to perverse incentives for GP discretionary over-servicing to fill patient lists and*

maintain their income by inducing demand in populations who remain able to afford services. Such over-servicing of populations typically manifests as over testing for rare or untreatable conditions and associated unnecessary treatment resulting from false positives, as well as over-treatment directly (e.g. over-medication)".

The funding and governance arrangements of Commonwealth taxpayer subsidisation of private medical services through Medicare discussed, demonstrate a number of issues for the development of the HORSt. First, the Australian constitution has enshrined the freedom of private practice for private medical practitioners. Combined with the episodic payment system for these practitioners, the MBS representing 28% in 2015-16 of Australian Government health expenditure (Australian Institute of Health and Welfare 2017a), these arrangements are unlikely to encourage on its own the efficient or equitable advancement of improved health outcomes that involve patients who require state hospital system care. In establishing a benchmark level of health outcomes for populations at the state level, the HORSt needs to therefore consider the inclusion of Medicare funding as a crucial productive component of the resourcing of the continuum of care. MBS data is available from the Commonwealth at small area population levels (Australian Institute of Health and Welfare 2018a; Department of Human Services 2016). A discussion surrounding the extent and application of this data to the HORSt is contained within Chapters Four and Five.

3.3 TAXPAYER SUBSIDIES FROM COMMONWEALTH TO PRIVATE HEALTH INSURERS

Australians are encouraged to take out PHI in Australia via financial incentives being;

- the PHI rebate, a taxpayer subsidised rebate, indexed to income level, to help cover the cost of the PHI premiums (Private Health Insurance Ombudsman 2017a);
- the Lifetime Health Cover loading, a progressing loading applied to future PHI premiums for not taking out coverage prior to a person's 30th birthday (Private Health Insurance Ombudsman 2017b); and
- the Medicare Levy surcharge, an additional rate of taxation charged over and above the Medicare levy for incomes above a threshold (Private Health Insurance Ombudsman 2017c).

The PHI rebate is paid directly to private health insurers. Income tested, this reduces the cost individuals and families face in premiums payable to the insurer (Private Health Insurance Ombudsman 2017a).

The goal of these incentives is to boost the coverage of PHI in Australia. In doing so it has long been purported by the Commonwealth Government that more Australians will use private hospitals for elective surgery, taking pressure off public hospitals (Boxall 2015). Contemporary PHI industry statements that have vested interests champion this view (Eddy 2016).

There is growing body of evidence, spanning many years, to suggest that these incentives however, have not relieved public hospital pressure (Boxall 2014, 2015; Duckett 2005; Duckett & Jackson 2000; Eckermann 2014a; Eckermann et al. 2016; Menadue & McAuley 2012; Savage & Lu 2006). Moreover, the effectiveness of these incentives in terms of equity and efficiency and particularly the size of the taxpayer subsidy of the PHI rebate and the opportunity cost that it represents have been questioned. i.e.

> *"Cumulative evidence since the introduction of the rebate in 2000 shows that despite spending growing to $6.0 billion in 2013-14 and projected to grow to $7.2 billion by 2017-18, the rebate has not taken pressure off the public health system. Rich, young, healthy populations joined for tax breaks and to avoid later higher premiums when older"*

(Eckermann et al. 2016, p. 8).

Russell (2015) argues that whilst PHI is incentivised and subsidised, it represents waste as there is no requirement for PHI to be used. This represents allocative inefficiency, whereby taxpayer funding is used to purchase a contingency rather than to fund services. Where it is not used, the subsidy supports PHI companies' bottom line.

In terms of the lack of use of PHI, Russell (2015) observes that around 25% of PHI holders choose to use the public hospital system. This finding runs contrary to the government expectations that PHI coverage would remove pressure from the public system. However, this finding can be somewhat expected, whereby patients face disincentives to use their PHI as electing to do so often involves significant out-of-pocket costs which in Australia can exceed US levels (Sivey 2016; Sweet 2012).

Eckermann et al. (2016) and Mihm (2016) find a significant portion of PHI is purchased to avoid taxation. Furthermore, Mihm (2016) finds that some low cost PHI policies are marketed by insurers as tax avoidance instruments rather than providing health benefits. Mihm finds that these policies are effectively "junk policies" with little if any benefits that can be used in private hospitals with approximately 1% of private hospital services covered by them. The implication of this is that by their lack of private benefits, these policies direct patients who need hospital care towards public hospitals. This is further evidence of allocative inefficiency and is diametrically opposed to contemporary industry views and that of Government that holding PHI takes pressure of the public system.

Congruent with the previous quote by Eckermann, Sheridan and Ivers, Harris (2013) maintains that even after means testing, the PHI rebate significantly rewards the wealthy. Menadue and McAuley (2012, p. 12) argue that this can create an inequitable demarcated health system of a private hospital system for the rich versus a public Medicare system for the poor. Contemporary statements by former Liberal Prime Minister, Malcolm Turnbull referring to Medicare as 'a safety net', reinforce this view that Medicare is for the less well-off (Duckett 2016). Duckett (2000, p. xxi) has long considered that labelling Medicare for the poor, damages social cohesion and weakens the equitable system of universality of Medicare whereby the rich do not see the value in contributing to a system that they view or are told is not for them.

Menadue and McAuley (2012, p. 16) summarise PHI in Australia as being allocatively and technically inefficient and failing to promote equity. i.e.

> *"To satisfy criteria of efficiency and equity, the best policy for the Government would be to withdraw all support for private health insurance. It is administratively expensive (technically inefficient in economists' terms), distorts incentives and choices (allocatively inefficient) and does not satisfy any reasonable criteria of equity".*

Additionally, Harris (2013) and Menadue (2017), argue that given that PHI is relatively expensive, that private hospitals could be better subsidised directly by taxpayers at an overall lower cost rather than via the taxpayer subsidies for the PHI rebate.

The abundant evidence in this section has shown that the distribution of the PHI rebate is skewed towards more well-off members of the community and that this distribution is significantly inefficient and inequitable. It follows that there is no evidence that the PHI rebate alleviates health inequities. It could be argued based upon this evidence that the PHI rebate actually contributes towards perpetuating health inequities, via the enormous opportunity cost of tax payer funding that could be otherwise provided to support an expansion of the public health system at lower cost, rather than support a risk contingency for the wealthy.

The PHI rebate, as inefficient as the literature has shown it to be, was nonetheless considered for inclusion as an input in the development of the HORSt benchmark. However, PHI data is not available at sufficiently low-level population structure to support its inclusion as a funding input within the HORSt and for this reason will not be included.

3.4 TAXPAYER FUNDING TO SUPPORT THE NATIONAL DISABILITY INSURANCE SCHEME (NDIS)

The NDIS is a social insurance scheme that supports people with permanent and significant disabilities under the age of 65. It commenced in 2016 and will be progressively implemented across Australia. It was developed to directly provide people with individualised support to enhance their quality of life and done so in recognition that the disability system in Australia was inefficient and inequitable (Fawcett & Plath 2014; Foster et al. 2016). The NDIS is an example of a person-based needs funding model, the type of which was discussed in the literature review.

The goal of the NDIS is to provide a multifaceted approach to support, for improving the lives of people with permanent and significant disabilities and their carers, across health, education and community services (National Disability Insurance Agency 2017). Whilst not a dedicated health program, taxpayers pay for the NDIS through a specific Medicare levy increase and consolidated revenue and both Commonwealth and states share funding contributions for the NDIS (Foster et al. 2016, p. 30). The National Disability Insurance Agency administers funding to individuals following assessment of needs (National Disability Insurance Agency 2017).

The NDIS commenced at piloted locations in 2013. The gradual roll-out across the country commenced in 2016 (National Disability Insurance Agency 2017). Given this and the somewhat enormous task of assessing individual clients for the level of support required and eligibility, it is too early to assess the NDIS in terms of effectiveness of advancing equity or efficiency. Nevertheless, disability has been identified as a significant determinant of health inequities, with people living with disabilities facing significantly poorer avoidable health outcomes (Australian Institute of Health and Welfare 2016a; Turrell et al. 2006). The intent of the program could therefore assist in the longer term towards addressing these health inequities. Moreover, of interest to this study, it is important to consider how the NDIS approaches equity and considers need. For example,

> *"Under the Scheme, (the NDIS) support is to be targeted to those with significant needs who require specialist rather than mainstream support and who are likely to benefit*

most by way of improved independence and social and economic participation" (Foster et al. 2016, p. 30)

This approach is aligned to the concept of vertical equity, where clients' needs in terms of their capacity to benefit for specific financial support will be individually assessed. This represents a departure from the Medicare principles approach of equality of access, horizontal equity and is more aligned, as discussed previously to what Mooney (2009) and (Culyer 1995) state as a more workable approach to need; that is need assessed in terms of capacity to benefit.

As a multifaceted insurance model, beyond improving health alone, taxpayer funding of the NDIS is not suitable to be included within the development of the HORSt. Disability however, as a significant predictor of health inequalities, is relevant to factors that can give rise to poorer health outcomes (Australian Institute of Health and Welfare 2010, 2016a). As such, variables that represent disability at the population level will be examined for their use to inform vertical equity loadings in Chapter Five.

3.5 TAXPAYER SUBSIDIES FROM COMMONWEALTH TO SUPPORT THE PBS

The PBS provides Australians with taxpayer subsidised medicines to make them more affordable. The Pharmaceutical Benefits Advisory Committee (PBAC) assesses the cost-effectiveness of drugs to be listed for subsidisation on the PBS and recommends to the Commonwealth government drugs to be listed (Department of Health 2017).

The PBS seeks to operate equitably based on the financial means of patients, whereby it currently operates with co-payments payable by the patient, with pensioners and concessional card holders paying $6.30 in 2017 for a prescription and non-concession patients paying a maximum of $38.80. Maximum expenditure annual safety nets also apply being $378 and $1494.90 respectively for concessional and non-concessional patients, with the cost of further prescriptions being respectively free or reduced to the concessional rate (Department of Health 2017). However, Palmer and Short (2014, p. 139) find that people with chronic illness typically on lower incomes face significant out-of-pocket co-payments irrespective of the safety net arrangements.

The PBS, like the MBS, can be also characterised as an output-based model, where each script produced is an output. Moreover, doctors also act as gatekeepers to the PBS, so the distribution of taxpayer subsidies is logically linked to this access.

Aligned to the arguments made for including the MBS in establishing resourcing for a benchmarked level of population health outcomes at the state level, the HORSt will also include PBS funding which representing 15% of the Australian Government expenditure on health care in 2015-16 (Australian Institute of Health and Welfare 2017a) and is therefore a crucial component of the resourcing of the continuum of care. PBS data is available from the Commonwealth at small area population levels(Department of Human Services 2016). A discussion surrounding the extent and application of this data to the HORSt is contained within in Chapters Four and Five.

3.6 OUT-OF-POCKET COSTS

In Australia out-of-pocket costs or co-payments occur whereby there is a gap between the reimbursement by Medicare (under the MBS) and the medical practitioner's fee. These costs are common and typify the nature of private medical practice in Australia dominated by general practitioners and specialists. For private hospital patients the gap is between the private insurance benefit, Medicare reimbursement and the fee (Paris et al. 2010) .

For a country that provides its citizens with universal access to publicly subsidised health insurance (Medicare), publicly subsidises prescription drugs (PBS), has one of the largest networks of public hospitals in the world that provide treatment free of charge and has punitive tax arrangements to encourage PHI coverage and publicly subsidies PHI premiums, it is puzzling that Australians face increasingly higher out-of-pocket costs as a proportion of household consumption, eclipsing that of the most expensive private system, the United States of America (USA) (Duckett et al. 2014, p. 4; OECD 2017a, p. 26). Unsurprisingly however, these rising out-of-pocket expenses present a significant problem for health funding inequity and where timely access to private primary care is compromised due to unaffordability it can lead to inequity of health outcomes whereby delay in seeking care can exacerbate illness. Out-of-pocket expenses have a significant impact on the most vulnerable members of society and the there is significant health inequalities evident in the data arising from people's ability to pay these costs and access services (Duckett et al. 2014; Kraft et al. 2009; Mollborn et al. 2005; Prentice & Pizer 2007).

The OECD reported in 2017 that 16.2 medical consultations per 100 people in Australia were avoided due to cost (OECD 2017a, p. 26; 2017b). In addition, at the time of this preparing this study, the

AIHW released data and a report on out-of-pocket costs in Australia. This is the first time such data has been available to the public. Summarising the data Russell (2018) found that:
"seven percent of Australians (an estimated 1.3 million people) said the cost of services were the reason that they delayed or did not seek specialist, GP, imaging or pathology services when they needed them".
Furthermore, the AIHW data highlights significant inequities regarding costs barriers to treatment across locations, with a defining trend of a lower number of people delaying or avoiding treatment due to cost in metropolitan areas of NSW 6.7% compared to NSW regional and rural areas 8.3% (Australian Institute of Health and Welfare 2018e).

The practice of excessive fees and price discrimination by Australia's private clinicians can be described as rent-seeking behaviour, whereby the financial extraction of such disproportionate fees is a non-compensated value relative to factor costs that contribute to production or the benefits received by the patients (Gross & Laugesen 2018, p. 771; Krueger 1974). The rent-seeking behaviour is systematic of the market failure associated with the information asymmetry between clinicians and patients and is associated with monopolistic power which ultimately compromises technical and allocative efficiency (Dunn & Shapiro 2014, p. 160; Ghosh 2008, p. 269).

Freed and Allen (2017) found that in Australia there is widespread differences in fees for service for: the same speciality / type of service; location; amongst states. At an extreme level there was more than a 400% difference in fees charged for the same speciality. This extreme range was found for multiple specialities. The implication of this is that out-of-pocket expenses would be difficult to justify as a variable that productively contributes to the resourcing of benchmarked health outcomes and as such the HORSt will not consider it in establishing the resource pool for the benchmark. However, in so far as that out-of-pocket costs represents inequity through people's inability to pay and consequently acts as a barrier to access, out-of-pocket costs will be considered in the HORSt as a variable that may contribute to explaining how social determinants influence health outcomes.

3.7 CHAPTER SUMMARY

This chapter has examined the funding and governance arrangements of taxpayer subsidies within the mixed private-public health system in Australia. Out-of-pocket expenses paid by individuals to health care providers were also examined. The ability of these funding transfers to promote equity and efficiency were critiqued in terms of their applicability for inclusion in the development of the

HORSt. Legislative issues that surround the Australian health care system were also examined for relevance to the HORSt development. The key findings are as follows.

The Medicare principles that all state governments must adhere to pertaining to timely and equal access for services will not be breached by the Development of the HORSt.

Given the nature of private medicine in Australia, which is dominated by constitutionally protected private medicine, taxpayer subsidisation of the MBS and the PBS is not subject to any resource distribution mechanism. As such, this taxpayer subsidisation cannot advance equity or allocative efficiency and the state health system is uniquely positioned to do so through resource distribution guided by health needs.

Taxpayer subsidies made to private doctors under the MBS fee-for-service and to the PBS which is gate-kept by private doctors are important components of the production of health outcomes. In a benchmarked model considering the allocative efficiency of health outcomes, the MBS and PBS will be important and necessary resource inputs for the HORSt to consider.

Taxpayer subsidies to the PHI rebate are inefficient. The literature also demonstrates that they are inequitable, tending to favour the more socially advantaged members of the community. Due to their significant inefficiencies and the fact they represent a risk contingency rather than a resource that is actively used, it is difficult to apply this variable as a resource input for the production of improved health outcomes. Data are also not available at the small population level required for the study (as per outlined in Chapter Five). The study will therefore not seek to include this variable in the development of the HORSt.

The NDIS is a multifaceted insurance model with expected benefits to improve people with disabilities lives beyond that of the health sector. Given this, the NDIS contribution to the production of health outcomes is unknown and will not be included in the HORSt benchmark. However, variables that represent disability within the population could be relevant predictors of the allocative efficiency of desired health outcomes and will be tested as predictors of health need within the model.

The enormous variation in out-of-pocket costs faced by Australians represents inefficiency and inequity. It is difficult to know whether this funding transfer from individuals to private doctors represents a resource contribution to health outcomes, or a rent-seeking contribution to abnormal profits. Data on out-of-pocket costs will not be included therefore as a resource input to the HORSt benchmark. However, this data for small populations will be tested for inclusion as a predictor of the allocative efficiency of the desirable outcomes to see whether or not the affordability of these costs affects outcomes.

CHAPTER FOUR - RESEARCH METHODOLOGY

4.0 INTRODUCTION

The previous two chapters reviewed the literature of the underlying key concepts surrounding health needs, equity and efficiency, public funding models, governance and funding arrangements and the limitations and conditions that Australian federalism imposes upon Australian state health systems. Developed from key findings and gaps in the literature, this chapter provides the methodology of the study, which applies the conceptual framework (page 88) underpinning the study.

The section below demonstrates that all necessary ethical approvals for this study were achieved. Following this, this chapter outlines the methodology for the development of the HORSt in the context of NSW as an econometric case study via four areas of discussion, which are:

1. An overview of the methodological approach underpinning the development of the HORSt and justification for the research methodology as a quantitative design.
2. The methodology supporting the development of the HORSt benchmark to inform the allocative efficiency of taxpayer resources expended across the continuum of care to produce health outcomes (approximated by measures of population health status).
3. The methodology for predictive modelling that identifies social determinants that give rise to the allocative efficiency of population health status and affect populations' ability to achieve benchmarked outcomes.
4. The methodology for operationalising the HORSt to inform vertical equity adjustments and resource distribution between the state and the LHNs so that equity of health funding across the continuum of care can be maximised.

Justification of data sources required to support the HORSt benchmark, predictive modelling and the population structures used for analysis are outlined in Chapter Five.

The chapter concludes with a summary of the research methodology.

4.1 ETHICAL APPROVAL

Consistent with paragraph 5.1.22 of the National Health and Medical Research Council (NHMRC) National Statement, *"research can be exempt from Human Research Ethics Committee (HREC) review if that research:*

(a) is negligible risk research; and
(b) involves the use of existing collections of data or records that contain only non-identifiable data about human beings.

In doing so, it needs to be recognised that a decision to exempt a research study from ethical review by the HREC is, in effect, a determination that the research meets the requirements of the National Statement and is ethically acceptable" (National Health and Medical Research Council 2015b).

According to the National Statement section the definition of where research is negligible risk is: *"where there is no foreseeable risk of harm or discomfort; and any foreseeable risk is no more than inconvenience. Where the risk, even if unlikely, is more than inconvenience, the research is not negligible risk"* (National Health and Medical Research Council 2015a).

In February 2017 a protocol was developed to support an application for the exemption of the study from ethical review by the Human Research Ethics Committee (HREC) as the study is a negligible risk on the basis of that there were no study participants and data to be used is de-identified and aggregated by age groups and sex at population levels. Specifically, the protocol identified the use of the following de-identified data:

- NSW aggregated hospitalisation data by age group and sex of the 22 Ambulatory Care Sensitive Conditions defined by the Australian Institute of Health and Welfare, for each NSW SA3 geographic area for the ten years 2006/07 to 2015/16.

- NSW aggregated hospitalisation data by age group and sex for Charlson-Comorbidities for each NSW SA3 geographic area for the ten years 2006/07 to 2015/16.

- NSW aggregated hospitalisation data by age group, sex, NWAUs, costs and program area for the ten years 2006/07 to 2015/16 for each SA3 geographic area and for each LHN.

- Volume and cost of Medicare Benefits schedule categories (1 through 10) based on date of processing by age group and sex for each SA3 geographic area for the financial years 2013/14, 2014/15, 2015/16.

- Total scripts and benefits paid for the Pharmaceutical Benefits Scheme (Normal Arrangements PBS and Special Arrangements PBS) for all patient categories based on date of processing by age group and sex for each SA3 geographic area for the financial years 2013/14, 2014/15, 2015/16.

- State health expenditure public hospital expenditure for LHNs and SA3 geographic areas measured by NWAUs for the years 2013/14, 2014/15, 2015/16.

- NSW Self-reported health survey data at SA3 level, aggregate by sex, age group and self-reported health scores (1 through 5) for the last ten years 2006/07 to 2015/16.

On 16 March 2017, Australian Health Services Research Institute (AHSRI) Deputy Director A/Professor Rob Gordon, reviewed the research protocol for the study and granted an exemption from ethical review by the HREC. As SWSLHN Epidemiology unit extracted NSW Health data, as a courtesy to the SWSLHN, a copy of the research protocol was also supplied to the SWSLHN HREC whom agreed that the research satisfies conditions of being exempt from ethical review by the HREC. Appendix 3 provides a copy of the ethics approval.

4.2 OVERVIEW AND THEORETICAL APPROACH

The literature reviews gaps, limitations and opportunities culminated in the study's conceptual framework (page 88) to support the study's aims and research questions. In response to this, the theoretical approach underpinning the HORSt involves three broad stages. These are:

1. The development of a measurable benchmark reflecting the allocative efficiency of the production of health outcomes for populations relative to the resource inputs across the continuum of care for those populations;
2. Identifying social determinants, that can represent populations' health needs in terms of populations' capacity to benefit, that predict populations' ability / inability to achieve the benchmark; and

3. Using the social determinant predictors of allocative efficiency as vertical equity funding adjustors that can be applied to populations that cannot achieve the benchmark.

It might seem counterintuitive to be rewarding populations that do not meet the benchmark with vertical equity loadings (a greater share of funding), however such a view does not consider the logic that health care funding at the population level cannot create incentives that impact on choices that individuals make, particularly in the mixed funding system of Australia. Furthermore, as demonstrated in the review of Governance and Funding arrangements in Chapter Three, Commonwealth government subsidised funding of private services under the MBS and the PBS are not subject to any distributive equity mechanism for populations and can exacerbate inequity. The overall goal of the HORSt that culminates in the third stage is to guide the allocation of state health funding from the state to geographical regions (LHNs). Funding shares are based on each LHN population's socially determined health needs and the affects these needs have on the LHNs populations' ability to achieve the benchmark, relative to the bulk of taxpayer funded resources consumed by the populations across the continuum of care.

The vertical equity loadings are therefore not rewarding inefficiency or poor performance per se; they are however compensating populations that have greater capacity to benefit, a greater need, which acts as barrier for achieving the benchmarked outcomes and with respect to the total pool of available tax payer funded resources which for this study will include MBS, PBS and State Public Hospital resources. Congruent with the literature reviews findings on the purpose of population needs-based funding instruments, the purpose of the loadings is to act as an enabler. The loadings represent an equity adjustment and promote allocative efficiency, by creating a more optimal mix of resources aligned to the production of more desirable outcomes. The loadings inform each LHNs HORSt need index and when applied to the total pool of available taxpayer funded resources show what residual amount is required to be adjusted by the State government so that equity of health funding can be maximised.

To reiterate, the HORSt methodology will work as only a first step in the state health funding model. ABF, identified in the literature review as being a compatible second step, is used to drive technical efficiency between the LHNs and the state health service providers / facilities. Furthermore, the HORSt methodology in supporting the first step in the funding model of guiding allocations from the state to LHNs will not consider patient flows; patients from one LHN being treated in another.

The conceptual approach underpinning the HORSt is somewhat analogous to the Gonski school resourcing standard (SRS) which, as depicted in the literature review, identified reference schools as a benchmark whereby they have an acceptable level of educational outcomes, measured by NAPLAN results and are located within populations that have social determinants aligned to achieving those outcomes. Gonski's model applies vertical equity loadings applied to schools that do not meet the benchmark and have social determinants know to give rise to poorer outcomes (Gonski et al. 2011).

The theoretical application of the HORSt is not unrealistically seeking to eradicate all the differences in health so that health is equalised across the population. The realistic goal to enable maximising equity, supported by the literature, should be to reduce or eliminate differences that result from factors that are considered avoidable and unfair (NSW Department of Health 2004, p. 1; Whitehead 1991, p. 220). Doing so responds to the literature that argues for need to be defined in the context of capacity to benefit and takes a vertical equity approach. This realistic approach is also aligned with the Gonski SRS that did not seek to have all students achieve identical outcomes, but rather seeks to reduce the avoidable barriers to educational outcomes so students have the same opportunities to achieve (Gonski et al. 2011, p. 153). As such the equity goal in the HORSt methodology is aligned with the promotion allocative efficiency with respect to factors that give rise to health needs of the population and the benchmark is a function of allocative efficiency, representing the health outcomes achieved by populations' relative to their funding inputs.

The publicly reported limitations of the Gonski model do not apply to the HORSt. First, a key criticism with Gonski is that it has no secondary mechanism (no ABF as in the case of the HORSt) to ensure that resource distributions recommended under the formula can be expended efficiently (Gannicott 2016, p. 16). Secondly, whilst Gonski was initially a tool of reallocation of current funding, it ultimately recommended more funding (Gannicott 2016, p. 10). The HORSt by contrast will not recommend additional health funding for the system. The HORSt is designed to act as instrument of resource distribution, involving some reallocation, but nonetheless presiding over a fiscal neutrality. Decisions of greater levels of funding are beyond the scope of the HORSt research and matters of policy determinations for the state government.

The theoretical foundation of the first stage of the development of the HORSt benchmark is to utilise PPHs as a proxy for health outcomes via a measure of health status at the population level. Doing so is an extension of the work of Duckett and Griffiths (2016b) which identifies "hot spots" (p. 3) of prolonged poorer health represented by PPHs which as discussed in the literature review are potentially preventable illnesses and representative of sicker patients and are found to be persistently high in areas of having lower socioeconomic status, remoteness and indigeneity. The HORSt application of this work is to take an ***inverse*** position of Duckett and Griffith's hot spots and consider establishing the benchmark where prolonged 'cold spots' exist, (geographical locations where population health status is observed to be good) and where the social determinants of health for those populations are favourable to achieve better health outcomes.

An alternative proxy of geographical population health status to using PPHs was also considered via an application of the Charlson comorbidity index. As discussed in Chapter Two, whilst primarily used as a tool of risk of mortality, the Charlson comorbidity index is a tested measure of health status, which has been used to evaluate health outcomes in many clinical settings. Again revisiting the literature review, similar to PPHs, the literature indicates that comorbidity is inversely related to socioeconomic status (Chang et al. 2016).

Also congruent with Gonski's approach that considers all sources of funding inputs to schools from private and public sources, the HORSt will consider the majority of funding applied to across the continuum of health care Australia. The publicly subsidised MBS and PBS funding and health funding of public hospitals are the most feasible and applicable sources of funding to be included. The inclusion of these variables is discussed further in next chapter encompassing data sources. These funding inputs within the HORSt across the continuum of care represent 73% in 2015-16 of Australian Government's and NSW expenditure in NSW on, Medicare reimbursement of private doctors, subsidised prescriptions and public hospitals (Australian Institute of Health and Welfare 2018b).

4.2.1 A quantitative design

Creswell (2008, pp. 51-5) and Leedy and Ormrod (2010, p. 107) summarise and outline criteria for the suitability of either quantitative and qualitative approaches to research design. Using their summary of the literature, the HORSt is justified as a quantitative study as it requires:

- using quantifiable measures to develop a benchmark for health outcomes relative to health funding inputs;
- a confirmatory / predictive approach; seeking to predict the effect of explanatory variables upon a benchmarked level of health outcomes so as to make vertical equity financial adjustments;
- understanding of the quantum of funding required to achieve the benchmark;

- measurable levels of adjustments to be made to data of the social determinants of health; and;
- requires an understanding of the relationship between variables and their underlying trends.

Furthermore, the HORSt benchmark reflects the allocative efficiency of health outcomes using proxy variables of population health status relative to funding inputs. In the second stage the predictive model considers variables that can represent population needs that give rise to allocative efficiency of the observed health status. Predictive methods are a subset of descriptive methodologies, which can be categorised within quantitative correlation methods (Creswell 2008, p. 359). These methods involve examining the predictive nature of the relationships between variables (McMillan 2010). The relevance of predictive methods to the research is demonstrated though abundant literature for investigating health needs in the context of funding models to alleviate inequities (Carr-Hill & Sheldon 1992; Ho 2001; McDermott et al. 1997; Mooney 2009; Mooney et al. 1991) and from this there is an expectation in the literature that operationalised funding determinations are transparent and verifiable by accessible quantitative data sets.

The three methodological stages of the HORSt are now appraised and contextualised to the research with supporting literature in sections 4.3, 4.4 and 4.5 respectively. The population structures within NSW LHNs used for the HORSt and the available data are justified and outlined in Chapter Five.

4.3 METHDOLOGY FOR THE HORST BENCHMARK – (HORST METHOD STAGE 1)

To measure the relative allocative efficiency of the health outcomes produced from resources applied across the combination of services of the continuum of care to different geographical areas, an analysis of the relationship between the combination of health inputs and health outcomes is necessary. Populations that are observed to have the best health outcomes relative to their funding inputs can serve as benchmark populations to those populations that are not as relatively efficient.

Within the literature, efficiency at its simplest level can be described as the productivity ratio between output and input, where more output per unit of input reflects greater relative efficiency (Wilson 1999, p. 918). In the context of the HORSt design, the outputs in these ratios are not health service outputs but proxies of population health status serving as a proxy for population health outcomes. As a ratio representing a fractional relationship, efficiency is logically constrained between 0 and 1. The following equations 1 through 3 expand this fractional relationship in more detail mathematically.

Equation 1

$$Efficiency = \frac{output}{input}$$

Equation 1 outlines the mathematical relationship of efficiency in its simplest form between a single output and input. However, where there are multiple outputs and inputs, efficiency is expressed as a weighted ratio as per equation 2 and 3 below. Weights are required as different outputs and inputs will have different contributions to the relative efficiency of each unit assessed (Farrell 1957, p. 254; Kao 2016, p. 19).

Equation 2

$$Efficiency = \frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs}$$

Alternatively, for a specific unit (t), this ratio in equation 2 can be expanded to demonstrate weightings (coefficients) to each input and output. This is illustrated in equation 3.

Equation 3

$$Efficiency\ unit\ t = \frac{u_1 y_{1_t} + u_2 y_{2_t} + \ \dots + u_i y_{i_t}}{v_1 x_{1_t} + v_2 x_{2_t} + \ \dots + v_i x_{i_t}}$$

where:

$$u_i = weight\ given\ to\ output\ i$$

$$y_{i_t} = amount\ of\ output\ i\ produced\ from\ unit\ t$$

$$v_i = weight\ given\ to\ input\ i$$

$$x_{i_t} = amount\ of\ input\ i\ used\ by\ unit\ t$$

Problematically in a multiple output / input model, as depicted in equation 2 and 3, there will be a necessity to appropriately assign weights to each side of the simple efficiency ratio so as to understand the relative efficiency (Charnes et al. 1978; Sherman & Zhu 2006b, p. 64).

This issue is relevant to the HORSt, where the benchmark sought will be the population/s that has the highest relative efficiency of producing desirable health outcomes (proxied by low rates of age sex standardised PPHs or Charlson Co-morbidities), given the multiple financial inputs identified in the literature across the continuum of care. The inputs being that of the expenditure of MBS, PBS and state health system funding. The weighting of what role each funding source plays in producing the outcomes is problematic and not solved through a simple ratio analysis.

An additional complicating dimension will be how environmental factors (the social determinants of health) that affect the relative efficiency are to be assessed. In order to then redirect funding to areas of need, the HORSt will then require a mechanism that predicts / explains the relative efficiency so as to make vertical equity financial adjustments on the basis of predictors that reflect these social determinants known to affect health outcomes.

An alternative to pursuing a model that considers the allocative efficiency of the bulk of the funding inputs across the continuum of care to produce desirable outcomes would be to arbitrarily set a benchmark around each population that can be shown to be exhibit prolonged cold spots (low / good rates of PPHs or Charlson Co-morbidities) and then consider the financial inputs that typify these areas as a benchmarked level of resourcing. A regression for environmental factors that give rise to the rate of PPHs could be conducted to see what adjustments need to be made to each population that have social determinants that give rise to poorer health outcomes. Gonski's school resourcing standard (SRS) used such an approach, identifying reference schools that met a desirable level of educational standards (outcomes) and then considered reference school costs to help inform the funding benchmark (Gonski et al. 2011, p. 225). However, such an approach is far more problematic with the HORSt regarding health services. Both funding for state public schools and state public hospitals in Australia have multiple sources of public and private funding, however there are some important key differences. In particular, the mixed funding which ultimately contributes to schools' educational outcomes are applied to one layer of educational delivery; schools. Contrastingly, the state health system health outcomes are more diversely interconnected to financial inputs of the continuum of care spread over multiple health care providers and services, many of which are outside the remit of the state health sector and all having different contributions to health outcomes. It is therefore necessary to adopt a model that can consider and weight the different inputs contributions across the continuum of care to the efficiency of producing health outcomes.

4.3.1 Data Envelopment Analysis (DEA)

Fortunately, econometrics has a solution that can be aligned to the development of the HORSt. The use of Data Envelopment Analysis (DEA) is now a common tool for measuring the relative efficiency of multiple entities, called in the DEA literature 'decision making units (DMUs)', within a group and with the flexibility of multiple outputs and inputs (Hoff 2007). DMUs can be any entity where the focus is upon efficiency and the DEA literature is replete with DMUs across many industries, for example: manufacturers (lo Storto 2018); energy providers (Pérez 2017); hospitals and health services (Ferrier & Trivitt 2013; Laspa & Priporas 2008); social welfare programs (Habibov & Fan 2010); banks (Sherman & Zhu 2006a); internationally compared health sectors (Berenguer et al. 2016); and regional health systems (Carrillo 2017). In the case of the HORSt, the populations within NSW can be considered DMUs.

DEA is a linear programming technique and was specifically developed by Charnes et al. (1978) to evaluate non-profit and public sector efficiencies to support benchmarking. DEA was specifically developed to consider multiple outputs and inputs and provided a unique solution to determining weights for factors. Using linear programming for each DMU, DEA determines a unique set of factor weights (coefficients) for each DMU which are favourable for the DMU to maximise its efficiency and which are feasible for all other DMUs (p. 431). In doing so, if a DMU is found to be inefficient there can be no conjecture regarding the weighting of its factors unduly contributing to the inefficiency. This is highly advantageous to the HORSt in avoiding having to arbitrarily set and justify weights for factor inputs of difference services across the continuum of care.

The efficiency scores produced are relative efficiency scores, as the linear programing applied to each DMU compares their efficiency to all other DMUs. DEA does this by identifying the best practice or relatively efficient units to all other units. It identifies the scale of inefficiency of the inefficient units compared to the best practice units. DMUs that are relatively efficient have an efficiency score of 1 (100%) whereas inefficient DMUs efficiency scores are greater than zero but less than 1. The benchmarked populations found to be the most efficient (100% efficient) are known in the DEA literature to be categorised as "peers" and the results of the peers and inefficient DMUs can be graphically plotted along a production frontier (Steering Committee for the Review of Commonwealth/State Service Provision 1997). Figure 12 (page 121) illustrates an example plot of the frontier.

DEA takes the form of an objective function where the objective is to maximise the efficiency score of each DMU, subject to the constraint that, when the same set of weights (coefficients) is applied to all other DMUS being compared, no DMU will be more than 100% efficient(≤ 1). This objective function is outlined in the following linear programing example provided by (Sherman & Zhu 2006b, p. 64).

DEA linear programing for calculating the relative efficiency score for each DMU

$$Maximum\ efficiency\ score\ DMU0 = Max\ \theta_o = \frac{u_1 y_{1_0} + u_2 y_{2_0} + \ldots + u_r y_{r_0}}{v_1 x_{1_0} + v_2 x_{2_0} + \ldots + v_m x_{m_0}}$$

subject to

$$Maximum\ efficiency\ score\ DMU1 = Max\ \theta_1 = \frac{u_1 y_{1_1} + u_2 y_{2_1} + \ldots + u_r y_{r_1}}{v_1 x_{1_1} + v_2 x_{2_1} + \ldots + v_m x_{m_1}} \leq 1;$$

$$Maximum\ efficiency\ score\ DMU2 = Max\ \theta_2 = \frac{u_1 y_{1_2} + u_2 y_{2_2} + \ldots + u_r y_{r_2}}{v_1 x_{1_2} + v_2 x_{2_2} + \ldots + v_m x_{m_2}} \leq 1,$$

.....

$$Maximum\ efficiency\ score\ DMUj = Max\ \theta_j = \frac{u_1 y_{1_j} + u_2 y_{2_j} + \ldots + u_r y_{r_j}}{v_1 x_{1_j} + v_2 x_{2_j} + \ldots + v_m x_{m_j}} \leq 1$$

whereby: $u_1 to\ u_r = coefficients\ of\ outputs\ 1\ to\ r > 0$;

$\theta_o to\ \theta_j = efficiency\ of\ DMUs\ 0\ to\ j$;

$y_1 to\ y_r = quantity\ outputs\ 1\ to\ r$;

$v_1 to\ v_m = coefficients\ of\ inputs\ 1\ to\ r \geq 0$; and

$x_1 to\ x_m = quantity\ inputs\ 1\ to\ r$

The linear programming described above is an extensive set of computations and constraints and as such DEA is typically calculated using modern DEA software packages. The software also helps orientate the programming so that DEA can be optimised for maximising efficiency subject to minimising the resource inputs or maximising the outputs and for considering economies of scale assumptions (Coelli 1996; Emrouznejad & Thanassoulis 2011; Hollingsworth 1997; Iliyasu et al. 2015).

Input or output orientation determinations for the DEA depend on the context of the study. Input orientated models seek to understand how efficiency can be maximised by using the least of amount of inputs for a given level of outputs (input minimisation). Output orientated models seek to understand how efficiency can be maximised by producing the maximum amount of outputs for a given level of inputs (output maximisation) (Cooper et al. 2011; Lee et al. 2016; Pascoe et al. 2003). Within the context of the HORSt the orientation is an output model, as per aim 1 of the study, the objective is to develop the HORSt benchmark so as to represent desirable or best health outcomes approximated by health status for LHNs' populations' relative to funding inputs across the continuum of care. An output DEA model for maximised positive health outcomes (minimising poor health) relative to the service inputs of the continuum of care is logical.

The DEA also needs to consider if efficiency is maximised under an assumption of constant returns to scale (CRS) or variable returns to scale (VRS). In Figure 12, examples of efficient frontiers under both models are plotted. Assuming in the examples an output-oriented model such as the HORSt, the frontiers define the maximum capacity output for the inputs. Under VRS the production capability of DMUs is assumed to exhibit variability, including increasing (IRS), CRS and decreasing returns to scale (DRS). Under CRS the production capability of DMUs is assumed to be constant; that is a doubling of all inputs will double output.

Figure 12 Example of DEA efficiency frontier under CRS and VRS – output orientation

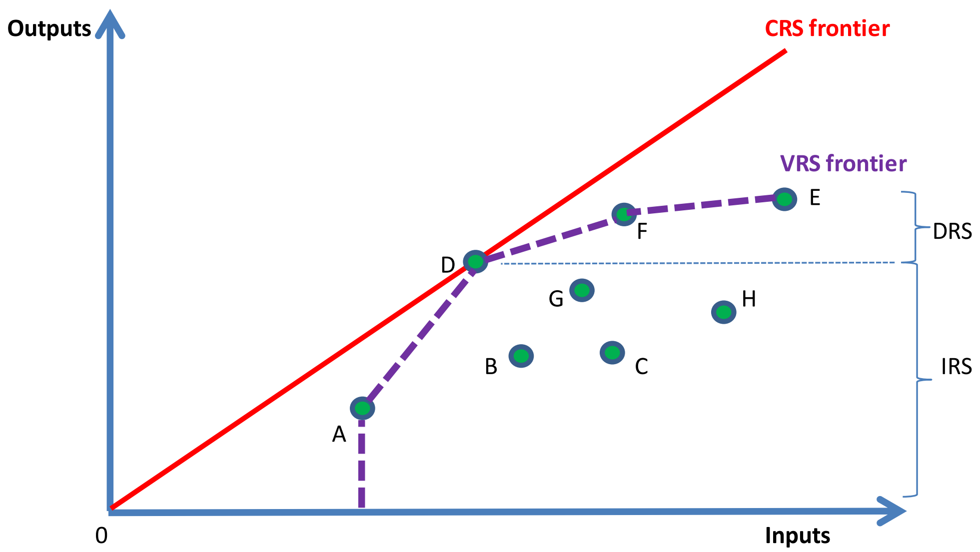


Figure 12 example adapted from (Cooper et al. 2011; Lee et al. 2016; Pascoe et al. 2003).

In Figure 12, under VRS, the DMUs A, D, F, E make up the VRS frontier (dotted line). These DMUs are efficient peers amongst the set of 8 DMUs (A through H) representing the maximum outputs per inputs. The peers are a relative benchmark for the relatively inefficient DMUs (B, G, C, H). Under CRS only DMU D is efficient being on the CRS frontier which is established proportionally between outputs and inputs. The assumption of CRS implies that a small DMU should be able to operate as efficiently as a large one (Santos et al. 2013). In the context of the HORSt, the returns to scale are not known. Notwithstanding this uncertainty, *a priori* reasoning is acceptable in the DEA literature to assume VRS (Cooper et al. 2011; Pascoe et al. 2003). In the context of the HORSt, as per the literature review and as will be shown in Chapter Five regarding data inputs and outcomes, there are observable differences in outcome, inputs, population sizes and access to health services amongst the populations (DMUs). Therefore, based on *a priori* logic, VRS will be assumed for the DMUs of HORSt DEA.

4.3.2 The goal and scope of the HORSt DEA

The goal for the HORSt will be that the data generating process of the DEA measures the relative allocative efficiency for each NSW SA3[10] populations' health status relative to all other NSW SA3 populations, subject to taxpayer inputs across the continuum of care. In doing so, the DEA will establish a meaningful benchmark that can be then utilised to examine populations' social determinants of health that affect the achievement of the benchmark. The DEA derived efficiency scores will serve as the dependent variable in the second stage of the methodology. This is now outlined.

4.4 PREDICTIVE METHODOLOGY FOR IDENTIFYING SOCIAL DETERMINANTS / HEALTH NEEDS – (HORST METHOD STAGE 2)

The DEA in stage one identifies the allocative efficiency of each population's health status (a proxy of population health outcomes) relative to the combination of health service inputs and relative to each other populations' allocative efficiency and populations who are 100% efficient. The second stage involves identifying variables within each population that predict or explain the variation in the efficiency scores. In doing so, the social determinants reflect health needs in the context of each population's potential capacity to benefit. The literature commonly refers to the combination of DEA and predictive modelling, as in the case of the first two stages of the HORSt, as 'two-stage DEA' "*where efficiency is estimated in the first stage and then the estimated efficiencies or, in a few cases, ratios of estimated efficiencies, are regressed"* (Simar & Wilson 2007, p. 32).

This approach for the HORSt will inform development of the need indices and consequently the third stage of the HORSt methodology discussed in section 4.5; involving vertical equity funding adjustments, based on the regression coefficients found to predict the variation in the DEA efficiency scores (the dependent / outcome variable in the regression).

The HORSt construct design that underpins the second stage uses the allocative efficiency of health status for each LHN's geographical populations as a latent variable. As guided by the literature review, two measures of population health status will be considered for the HORSt. These are age-

[10] SA3 are small area populations and a metric of the ABS. These are defined and justified in the data chapter, chapter 5.

standardised rates of PPH and age-standardised rate of comorbidity measured by Charlson scores. Chapter Five outlines and justifies which of these data elements will be ultimately used.

The selection of independent / explanatory variables sought to explain the variation in the allocative efficiency of health status derived from the DEA need to be considered in terms of whether they give rise to or form of the dependent variable or whether or not they reflect it. Jarvis (2014), Diamantopoulos and Siguaw (2006) and Bagozzi (2011), explains that the formative or reflective nature of a construct depends upon the conceptualisation of the latent variable. Health status for example can be a latent variable within either a formative or reflective construct. Conceptually for example, in a formative construct, illness or disability could be formative indicators, as they give rise or form to health status. In a reflective construct, a person or population's health status can be reflected in for example, the measurement of physical functioning, wellbeing and general health perceptions, or in health system costs. However, in the research construct the population health status being sought is a level of health outcomes for populations. As discussed, it is observed in the literature that the

"social and economic conditions and their effects on people's lives determine their risk of illness (health status) *and the actions taken to prevent them becoming ill or treat illness when it occurs"* (Commission on Social Determinants of Health 2008a).

From this definition, it is apparent that social determinants give rise to or form the risk of illness (health status). As such, a formative construct, as illustrated in Figure 13, is appropriate for the HORSt second stage methodology that considers populations' social determinants that explain the variation in the allocative efficiency of health outcomes, approximated by variables that represent populations' health status.

Figure 13 An example of a formative construct supporting the HORSt second stage methodology

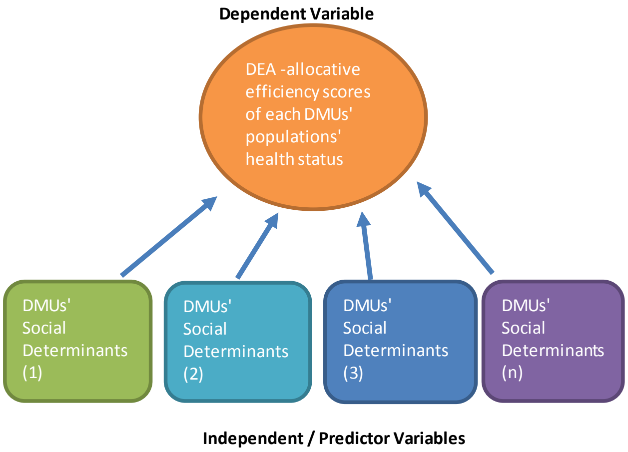


Figure 13 adapted from (Petter et al. 2007, p. 626).

The nature of the formative construct is an important consideration for the selection of variables to support the predictive modelling to ensure construct validity of the model. Variable selection is discussed in Chapter Five.

A key challenge for the predictive statistical modelling is that DEA uses a linear programming (non-statistical / nonparametric) approach. This means that the DEA scores derived from the linear programming are ***estimated*** and makes no allowance for error (noise) in sampling variability. As such, DEA cannot afford accuracy of the efficiency estimates being representative of the population and regression modelling used for predictive modelling of the estimates is not possible (Assaf & Matawie 2010, pp. 3,549). However, there is a substantial body of literature that demonstrates the wide spread use of two-stage DEA that employs regression modelling after estimating confidence intervals and statistical parameters for each of the efficiency scores is conducted using a process called bootstrapping (Aly et al. 1990; Amold et al. 1997; Banker & Johnston 1994; Barlos 2004; Burgess Jr & Wilson 1998; Byrnes et al. 1988; Carrington et al. 1997; Chilingerian 1995; Chilingerian & Sherman 2011; Chirikos & Sear 1994; De Borger & Kerstens 1996; Desli & Ray 2004; Dusansky & Wilson 1994; Fried et al. 1999; Garden & Ralston 1999; Gillen & Lall 1997; Gonzalez & Barber 1996; Kooreman 1994; Lovell et al. 1994; Luoma et al. 1996; McMillan & Datta 1998; Okeahalam 2004; Simar & Wilson 1998, 1999).

Coelli et al. (2005, p. 202) contextualising bootstrapping to DEA states that it consists of:

"using a random selection of thousands of 'pseudo samples' (using simple random sampling with replacement) from the observed set of a sample data. 'Pseudo' estimates can then be obtained from each of these samples. These thousands of pseudo estimates form an empirical distribution of the estimator improving the accuracy of DEA-efficiency analysis of interest. The distribution is then used as an approximation of the true underlying sampling distribution".
The literature finds that bootstrapping affords valid statistical inference to permit second stage DEA predictive modelling and that it also useful for sensitivity analysis of the DEA efficiency estimates using the generated confidence intervals (Coelli et al. 2005; Simar & Wilson 1998, 1999, 2007).

Initially the preliminary modelling for this study, guided by the two stage DEA literature, used bootstrapped DEA mean efficiency scores for the HORSt. However, Coelli et al. (2005, p. 203) outlines that the use of bootstrapping DEA data is questionable when the whole population data is used, rather than a sample. i.e.
*"For example, when one has data on all hospitals in a particular region or census data, the data is noise free as it represents all DMUs in the population and the DEA frontier obtained must be the true frontier. That is, in this case the frontier has been **measured** and not **estimated**. Hence there is no need to consider sampling variability"* (emphasis added).
This situation is applicable to the HORSt, whereby the data to be used for the outputs and inputs of the DEA, outlined in Chapter Five, is for all populations across NSW. Given this, bootstrapping is not required and will not be used for the DEA efficiency scores. The resulting scores for each DMU are relative ***measures*** of allocative efficiency, relative to all other DMUs.

4.4.1 Regression for the second stage DEA

Regression analysis is a form of predictive modelling that investigates the explanatory relationship between variables. Specifically, a regression analysis takes the form of a linear model between an outcome variable (dependent variable) which is predicted or explained by one or more independent variables (Seber & Lee 2003). The linear model takes the form of that shown in equation 4.

Equation 4 - Linear regression model

$$Y_i = b_0 + b_1 X_i + \epsilon_i$$

whereby: $\boldsymbol{Y}$ = the outcome variable;
$\boldsymbol{X_i}$= the predictor variable(s);

$\boldsymbol{b_1}$ = the regression coefficient associated with the predictor;

$\boldsymbol{b_0}$ = the value of the outcome when the predictor is zero; and

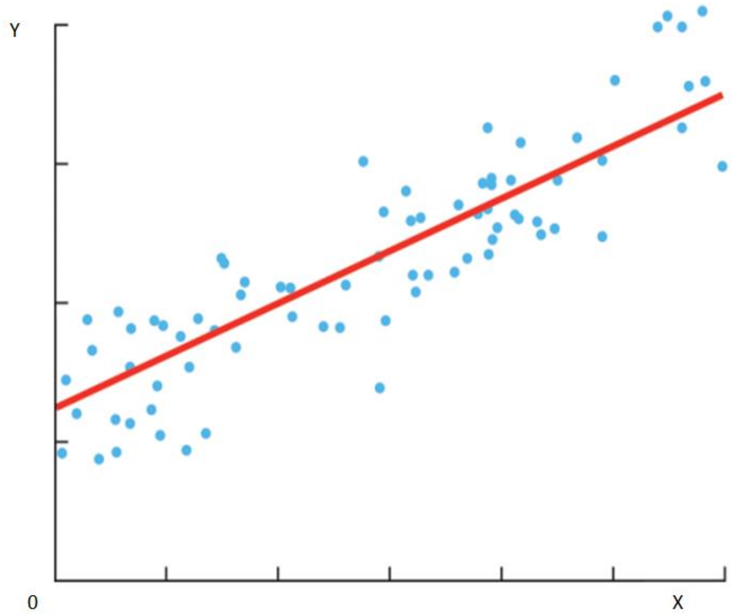
$\boldsymbol{\epsilon_i}$is an error term.

(Field 2013, p. 883)

The interpretation of the regression coefficient is that as the independent / predictor variable increases by one unit, the value of the outcome / dependent variable increases by the value of the coefficient. Where the regression has multiple predictors, the effect of each independent variables on the dependent variable is subject to holding the effects of all other covariates constant (Field 2013, p. 339). The error term in the regression model reflects that independent variables will not perfectly predict the outcome (Gallo 2015).

A regression model is an appropriate model for the HORSt, investigating factors $\boldsymbol{X_i}$ that explain the variation across DMUs' (populations') efficiency scores (the dependent variable $\boldsymbol{Y}$). However, there are various forms of regression and the "choice often depends on the kind of data you have for the dependent variable and the type of model that provides the best fit" (Frost 2018b). The best fit refers to how well the data fits the predicted linear equation (Chatterjee & Simonoff 2013, p. 5), depicted in the simple example in Figure 14 as the red line, which is the expected value of Y given the value of X. The dots are data points.

Figure 14 Example of a basic regression between two variables X and Y



Source for Figure 14, adapted from (Gallo 2015, p. 5).

A statistic known as R-squared (R^2) indicates the fit of the data in the model. Ogee et al. (2013) provides defines R^2 as:

"*the percentage of the response variable variation that is explained by a linear model.*

- R-squared = Explained variation / Total variation
- R-squared is always between 0 and 100%:
- 0% indicates that the model explains none of the variability of the response data around its mean.
- 100% indicates that the model explains all the variability of the response data around its mean.

R^2 is known as a coefficient of determination and represents the proportion of the variance in the dependent variable that is predictable from the independent variable(s)."

It follows from this explanation that a regression model with higher R^2 can explain more of the variance in the dependent variable from the predictors. However, caution needs to be applied with seeking a higher R^2 as a goal for the regression. This is because R^2 will always be larger if more predictor variables are added, even if due to random chance alone, so the issue becomes whether or not the larger R^2 represents a significantly better fit of the data, whereby the regression axioms (discussed in the next subsections) are not violated and where the regression significance has been established (Field 2013, p. 324; Ogee et al. 2013). The literature indicates that there is no specific rule on how large an R^2 ought to be for the regression to be considered useful, as it will largely depend on the context of the study and any necessary transformations that have been applied to the data to fit the context of the study and or meet necessary regression assumptions (Frost 2017a; Nau 2018).

In the context of the HORSt second stage methodology, the regression should represent a description of what social determinants effect health outcomes and provide guidance to predictors that can be applied in the third stage as vertical equity funding adjustors. In this context, the HORSt will consider statistically significant R^2 size alongside how logical the description of the model's independent variables is in describing the underlying relationship with the dependent variable with respect to the underlying literature that guides the choice of the independent variables.

Overall, the key objective of the regression for the HORSt will to develop a parsimonious model; a model that offers the simplest explanation of predicting the variation in the allocative efficiency scores of the DMUs, so that the data fits the linear equation. Typically in a regression, parsimony is achieved when the minimum number of independent variables affords an adequate explanation of the variation in the dependent variable (Berenson et al. 2013, p. 536; Vandekerckhove et al. 2015, p. 3).

4.4.2 Linear regression assumptions and test procedures

Before discussing the underlying data for the regression to be used in Chapter Five, it is important to outline the key assumptions that must be met in order to be confident that the results can be generalised. Appendix 7 on page 318 provides a summary of these key assumptions and outlines the methodological tests that will be applied to the HORSt regression to ensure that the regression results are robust. The outcomes of these tests for these assumptions will be presented in the results section in Chapter Six.

4.4.3 HORSt Regression

Within the two-stage DEA literature, the type of second stage regression modelling applied by researchers varies. According to Simar and Wilson's (2007, p. 33) seminal paper and review of two stage DEA methods, they find that most researchers have used Ordinary least Squares (OLS) regression, or a Tobit regression, a type of censored regression. Briefly, these techniques can be defined as follows:

- OLS – the most common form of linear regression, often just known as linear regression, provides best estimates of the model when all assumptions for linear regression (those defined in the appendix 7 page 318) are met (Frost 2018a).
- Tobit regression – provides maximum likelihood estimates of linear relationships between variables when the dependent variable is either left-and / or right censored (restricted) due to measurement constraints. Examples of censoring include a model of data measured from a scientific gauge that provides a range of values of some phenomena being measured, where the true measure of some of the data observations may lie beyond the range of the gauge yet are recorded at the gauges maximum or minimum. In such cases a regression would require censoring to eliminate observations at the maximum and / or minimum. (UCLA Statistical Consulting Group 2018).

The divergence in the literature between these approaches is that some researchers claim that the nature of DEA efficiency estimates, bound between 0 and 1 mean that conventional linear regression modelling, such as OLS, should not apply and that a Tobit regression is appropriate

(Ahmad et al. 2017; McDonald 2009; Simar & Wilson 2007). However, as argued by Raheli et al. (2017), Simar and Wilson (2007), McDonald (2009), Ramalho et al. (2010) a growing body of literature indicates that such a position is false, whereby all DEA scores being a fractional relationship of outputs to inputs will logically be bound by 0 and 1 and are not censored. It follows that the use of Tobit regression in DEA, despite being widespread is questionable. Based on this literature the HORSt will utilise OLS regression. The OLS regression will be computed using SPSS v24 software (IBM Corp 2017).

4.5 UTILISING SOCIAL DETERMINANTS / HEALTH NEEDS AS VERTICAL EQUITY FUNDING ADJUSTORS TO INFORM LHNS SHARE OF STATE HEALTH FUNDING – (HORST METHOD STAGE 3)

The population structures in this study that represent the DMUs are ABS population structures known as Statistical Area level 3 (SA3s). There are 88 of these used in the study that span within and across the 15 NSW LHNs. These are discussed and justified for their selection in the next chapter which outlines the data sources for the study.

After the regression equation for the two-stage DEA is established with independent variables that represent social determinants that give rise to the allocative efficiency of the health status of the population, the predicted efficiency scores are calculated for each DMU / SA3 population. From this calculation, the SA3(s) that are predicted to be the most efficient represent the benchmark. Equation 5 shows the calculation of the predicted allocative efficiency scores for each population area using the regression with independent variable x_1 to x_n. The actual number of independent variables used in the regression will be ascertained through the regression analysis outlined in the results in Chapter Six.

Equation 5- Predicted Allocative Efficiency of each DMU / SA3

$$\hat{y} = b_0 + b_1 x_1 + b_2 x_2 + b_n x_n$$

where: $\hat{\boldsymbol{y}}$**=** the predicted efficiency score of each **SA3**

$\boldsymbol{b_0}$ = the value of the outcome when the predictor is zero, the regression constant;

$\boldsymbol{x_1}$= predictor / independent variable $_{\mathbf{1}}$;

$\boldsymbol{b_1}$ = the regression coefficient associated with the predictor / independent variable $_{\mathbf{1}}$;

$\boldsymbol{x_2}$= predictor / independent variable $_2$;

$\boldsymbol{b_2}$ = the regression coefficient associated with the predictor / independent variable $_2$;

$\boldsymbol{x_n}$= predictor / independent variable $_n$; and

$\boldsymbol{b_n}$ = the regression coefficient associated with the predictor / independent variable $_n$.

A health needs allocative efficiency index, the HORSt needs index for each SA3 (equation 6), is then created by computing a ratio of the best predicted efficiency score to the predicted scores of each DMU. Doing so enables a vertical equity funding adjustment to be made to SA3s that have social determinants that limit the ability of the health service inputs across the continuum of care to achieve allocative efficient desirable health outcomes.

Equation 6- HORSt needs index for SA3s

$$n_i = \frac{PB}{PAE_{\ i}}\ x\ 100$$

where:

- $\boldsymbol{n_i}$**=** The HORSt need index for **SA3**$_i$;
- $\boldsymbol{PB}$ = the highest predicted allocative efficiency score of all SA3 populations (the predicted benchmark); and
- $\boldsymbol{PAE_i}$ = the predicted allocative efficiency score of **SA3**$_i$.

The index generated shows the socially determined health needs of each SA3 population as a proportional difference to the benchmark. The index number of 100 represents the benchmark, which is the lowest value for the index. Shown below in equation 7 is a hypothetical example for a fictional $SA3_z$ having a predicted efficiency score derived from the HORSt regression of 75.2 and whereby the benchmarked SA3 had the highest predicted efficiency of any SA3 of 98.6. This yields for $SA3_z$ a need index of 131, having social determined health needs 31% greater than the benchmarked SA3 population.

Equation 7- HORSt needs index –hypothetical example

$$HORSt\ SA3_z = 131 = \frac{best\ predicted\ efficiency\ 98.6}{Predicted\ AE\ SA3_z\ 75.2}\ x\ 100$$

Since NSW SA3 populations can sit wholly within or across multiple LHNs, each LHN's HORSt need index is built up from the SA3 need indices weighted for the SA3's population proportions that make up the LHN. Equation 8 outlines this which is identical to how needs indices at the LGA level were apportioned within the former NSW RDF and EHUIs to LHNs (Inter-Government & Funding Strategies 2005a; Marshall & Slater 2015). The HORSt need index for each SA3 is apportioned to each of the LHNs whereby the HORSt need index in each SA3 is multiplied by the portion of the SA3's population in the LHN as per the 2016 Australian Census. Each SA3s need adjusted population portion of the LHN is then summed to calculate the HORSt need index for the LHN.

Equation 8 – HORSt need index of LHNs

$$(N)_t = \sum_{i=1}^{n} (n_i \ x \ \% \ SA3 \ pop_i in \ LHN_t)$$

Where:

- $(N)_t =$ the HORSt need index for LHN_t;
- n_i = the HORSt need index for $SA3_i$; and
- $\% \ SA3 \ pop_i in \ LHN_t$ = the portion of the population of $SA3_i$ in LHN_t as per the 2016 Australian Census.

Table 7 is a worked hypothetical example that utilises equation 8 to apportion six theoretical SA3s ($SA3_i$ to $SA3_n$) need indices to an LHN(t) where the SA3s are contained wholly or partially within LHN(t). In this example the resulting LHN need index is 132.02.

Table 7 Example of apportioning SA3 need indices to the LHN

LHN(t)	A	B	C = A x B	D = C / Sum of C	H	HNI =the sum of (H x D) for each SA3 in the LHN (i to n)
SA3s within LHN	**Pop share of SA3 in LHN (t) 2016 Census**	**SA3 Pop 2016 Census**	**SA3 Population in LHN (t) = Population share of SA3 in LHN (t) x SA3 population**	**Proportion of Total Population for LHN in each SA3 = SA3 population in LHN (t)/ Sum of SA3 population in LHN**	**HORSt need index of SA3s in the LHN (i to n)**	**HORSt Need index of each SA3 x Proportion of Total Population for LHN in the SA3 = need index**
i	0.277%	72073	199.80	0.0005	125.479	0.0618
j	100.000%	77934	77934.00	0.1922	144.997	27.8636
k	100.000%	92470	92470.00	0.2280	133.960	30.5439
l	99.978%	133292	133262.69	0.3286	122.923	40.3917
m	100.000%	101617	101617.00	0.2506	132.265	33.1407
n	0.146%	49059	71.69	0.0002	120.020	0.0212
		Total	405555.18	1.0000		132.0230

Once each of the LHNs have a need index built up from the SA3 indices, these indices can inform socially determined needs-based shares of funding to assist with resource allocation decisions from the state government to each of the LHNs. These needs-based shares are calculated through the series of equations 9 through 12, which are the same calculations that have been applied in the NSW RDF and EHUIs for ascertaining the resource allocation shares from RDF and EHUI need indices (Inter-Government & Funding Strategies 2005a; Marshall & Slater 2015).

First, each LHN's 2016 Australian Census population is multiplied by its need index which derives a needs adjusted population (equation 9) which is logically greater than the actual population, inflated by the need index. The sum of all the LHNs needs adjusted populations is then calculated, which is the total state needs adjusted population (equation 10). Again, being needs adjusted this total exceeds the actual NSW state population.

Equation 9– LHN needs adjusted population

$$x_i = N_i \times P_i$$

where:

- x_i = needs adjusted population of LHN_i;
- N_i = HORSt need index of LHN_i; and
- P_i = 2016 Australian Census population of LHN_i.

Equation 10– State needs adjusted population

$$\sigma = \sum_{i=1}^{n} x_i$$

where:

- σ = NSW state needs adjusted population
- x_i = LHN_i needs adjusted population

The individual LHN needs adjusted populations are then normalised back to the actual state population by calculating their proportional share of the state needs adjusted population, by dividing each LHNs needs adjusted population by the state needs adjusted population and then multiplying by the actual NSW state population from the 2016 Australian Census (equation 11).

Equation 11– LHN needs normalised population to 2016 Census population

$$\alpha_i = \frac{(x_i)}{\sigma} \text{ x } S$$

where:

- α_i =needs normalised population of LHN_i
- x_i = LHN_i needs adjusted population
- σ = NSW State needs adjusted pop
- S = NSW 2016 Australian Census population

Finally, each LHNs socially determined health needs share of resources, their HORSt share, is calculated by then dividing the LHNs needs normalised adjusted population by the NSW population from the 2016 Australian Census (equation 12). The HORSt LHN shares of resources will be subject to comparison to the currently used EHUIs and the LHNs populations currently reported use of resources.

Equation 12– LHN HORSt share of resources

$$HORSt\ LHN\ share\ of\ funding\ \%\ \ (\epsilon)_i = \frac{(\alpha_i)}{S}$$

where:

- (ϵ) = HORSt share of resources for LHN_i;
- α_i =needs normalised population of LHN_i
- S = NSW 2016 Australian Census population

4.5.1 Resource Allocation guidance using the HORSt

Once the HORSt share of funding is known for every LHN, representing the health needs of the LHNs, resource allocation decisions between the State and LHNs can be guided by summing the total MBS, PBS and state health public hospital resources together and comparing what each LHN's share of these resources are compared to what they would be if the HORSt shares were applied. The difference between the actual consumption of resources across these three inputs of the continuum of care and that guided by the HORSt is the quantum of funds required to be adjusted by the state health system in order to maximise equity. As discussed, the HORSt informs the state health funding requirement as a residual adjustment after the taxpayer subsidisation from other relevant Commonwealth government funding has been considered. In other words, the HORSt represents what the state needs to spend for population equity, given that the state cannot control the Commonwealth contribution spending in the private sector.

4.6 CHAPTER SUMMARY OF METHODOLOGY APPLIED

This chapter has outlined and justified the methodology for the development of the HORSt.
In summary:
The HORSt benchmark methodology makes use of:

- Utilising DEA whereby the data generating process of the DEA measures the relative allocative efficiency for each NSW SA3 populations' health status relative to all other NSW SA3 populations, subject to taxpayer inputs across the continuum of care;
- The DEA model to support the benchmark is an output orientated model that seeks to maximise output relative to inputs and assumes based on *a priori* reasoning variable returns to scale;
- Population health status is the DEA output variable, which can be approximated by rates of PPHs or Charlson comorbidities (discussed in further detail in Chapter Five); and

- The main taxpayer funding inputs across the continuum of care from Commonwealth and NSW government for MBS, PBS and state public health outputs will be used as the resource inputs in the DEA (discussed in further detail in Chapter Five).

The HORSt predictive modelling methodology makes use of:

- An ordinary least squares regression;
- The measured DEA allocative efficiency scores for each NSW SA3 populations' health status will be the dependent variable;
- Testing explanatory variables from the Australian 2016 census and reputable secondary data sources that are demonstrated in the literature to represent social determinants of health and can give rise or form in a formative construct to the allocative efficiency of populations' health status.

The HORSt informs LHNs shares of funding using vertical equity loadings. These loadings and LHN shares are constructed using:

- The regression coefficients to calculate the predicted allocative efficiency for all populations';
- The ratio of individual predicted allocative efficiency scores for each SA3 population compared to the most efficient SA3 population inform need indices for each SA3 population; and
- Population weighted need indices for each SA3 population as proportions of the LHNs that contain them inform LHN needs-based shares of funding.

The HORSt results for LHNs shares of funding will be compared to the current LHNs shares of state health inpatient resources by area of residence and will also be compared to the current EHUIs shares of resources.

CHAPTER FIVE - DATA SOURCES

5.1 DATA SOURCES

This chapter outlines and justifies the data sources and their application used in the study. First the population level structures are outlined for inclusion, with limitations examined due to the availability of Commonwealth Government supplied data. DEA data inputs and output data are then justified in alignment with data availability and the literature presented. Data standardisation and applicable transformations required to support the methodology are outlined and justified. Finally, variables to be considered for inclusion in the regression analysis are appraised.

5.2 POPULATION LEVEL STRUCTURES

As the HORSt ultimately will inform resource distribution for LHNs from the state government, it is logical and necessary to utilise population level data structures that can support the DEA and regression analysis. As indicated in the previous chapter, the population structure will inform the DMUs of the DEA. The ABS data that will be utilised in this study is available at different levels of aggregation for populations and geographies. Since 2011 the ABS use Australian Statistical Geography Standard (ASGS) and within this is an ABS structure which provides a hierarchy of geographical areas developed for the release of ABS statistical information. Figure 15 depicts the ABS Structures, showing the hierarchy of areas and their component statistical areas and how they interrelate. The ABS main population and census structures are stable for 5 years (Australian Bureau of Statistics 2017d).

Figure 15 *The ASGS ABS Structure*

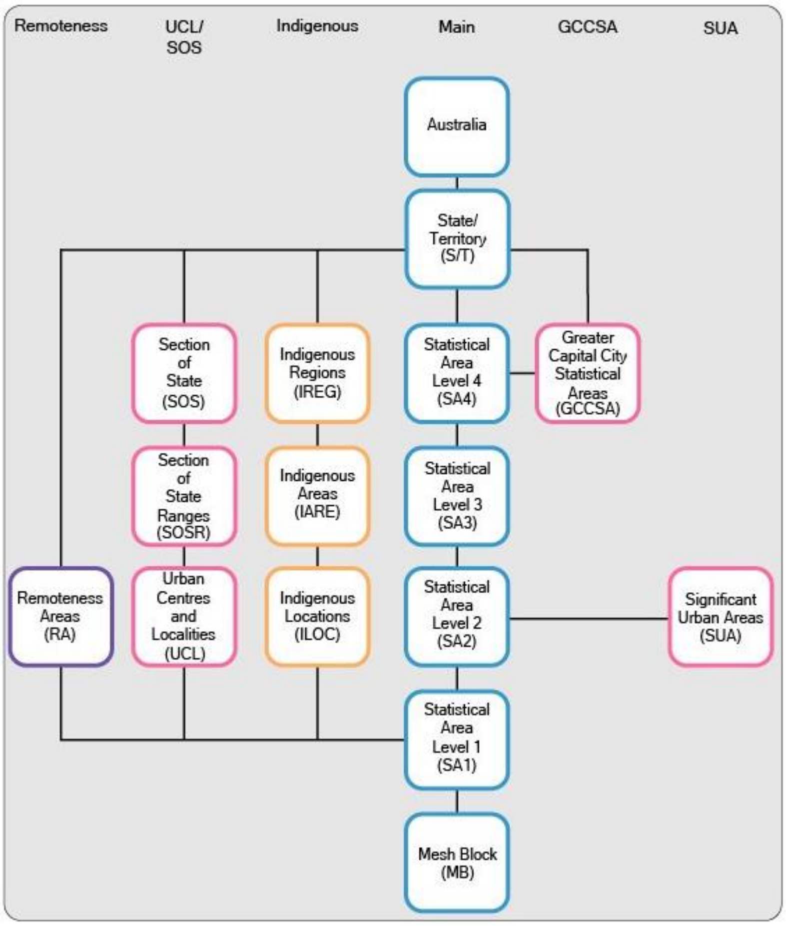


Figure 15 source: ABS website Australian Statistical Geography Standard (ASGS) (Australian Bureau of Statistics 2017d)

Small population clusters are sensible structures to study to inform geographical health needs. For example, the previous NSW Health Needs Indices (EHUIs) study used Statistical Area Level 2 (SA2) ABS geographies (Health Policy Analysis 2014b, p. 14). These generally have a population range of 3,000 to 25,000 persons and have an average population of about 10,000 persons. SA2s in remote and regional areas generally have smaller populations than those in urban areas (Australian Bureau of Statistics 2016c). In addition, the ABS definition SA2 geographies:
"aim is to represent a community that interacts together socially and economically" (Australian Bureau of Statistics 2016c).

As identified in the literature and methodology chapter, core resource data for assessing the publicly provided and subsidised resources across the continuum of care includes MBS and PBS data and these will be utilised as DEA inputs variables discussed in section 5.3.2. However, the Australian

Government Department of Human services have stated following requests for this data, that the smallest geographical level that they supply de-identified aggregated data by age and sex is the Statistical Area Level 3 (SA3) level (Slater 2017).

Across Australia, SA3 ABS geographies typically have population sizes of between 30,000 and 130,000 people, though there are some exceptions. The ABS states that the SA3s:
"provides a standardised regional breakup of Australia. The aim of SA3s is to create a standard framework for the analysis of ABS data at the regional level through clustering groups of SA2s that have similar regional characteristics. SA3s are built from whole SA2s. Whole SA3s aggregate directly to SA4s in the Main Structure. SA3s do not cross state / territory borders" (Australian Bureau of Statistics 2016c, 2016d).

Given the restriction that the smallest geographical structure for the provision of MBS and PBS data is SA3, this study utilises SA3 geographies for this study. There are two versions of SA3 geographies since the commencement of ASGS, 2011 and 2016 with some minor changes between the two and mapping available between them (Australian Bureau of Statistics 2016b, 2017d). The MBS and PBS data were supplied with the 2011 version which forms the basis of the SA3 geographies used in the study. All variables identified for consideration in this study, outlined in this chapter, are available or able to be derived at the 2011 SA3 level (hereafter referred to as SA3/s). As per the ABS definition above, SA3s are wholly contained within states borders. In NSW there are 91 SA3 geographical areas having an average population of about 83,000 people (Australian Bureau of Statistics 2016d). A discussion of the virtues of using SA2 data in the future is included in Chapter Seven.

It is important to note that 34 SA3 geographies do not fit precisely within the boundaries of the 15 NSW Health LHN boundaries. The NSW LHNs are defined by 2011 Statistical Local Areas (SLAs) (SLHD Planning Unit 2013) which are contained either wholly or partially within Local Government Areas (LGAs) boundaries (Australian Bureau of Statistics 2001). LGAs are not part of the ABS ASGS that commenced in 2011, but were part of the ABS Australian Standard Geographical Classification (ASGC) prior (Australian Bureau of Statistics 2017d). However the ABS has available "*Non-ABS Structure LGA Boundaries and Correspondences*" for 2011 boundaries (Australian Bureau of Statistics 2012), which allows for concordance mapping between structures.

To support the third stage of the HORSt methodology outlined in section 4.5 (page 129) which informs resource distribution shares for each LHN and to provide an understanding of the resource inputs and outcomes for LHNs, the HORSt results for the 15 NSW LHNs are built up from NSW SA3 geographies and apportioned to LHNs on the basis on each SA3's population needs and the population proportion of each SA3 within each LHN. The portion of SA3 populations found within each LHN is based on the 2011 ABS LGA and SA3 structures and 2011 ABS concordance mapping showing the LGA population apportioning to corresponding SA3 geographies (Australian Bureau of Statistics 2012). The most recent population projections of SA3s from the 2016 Census (Australian Bureau of Statistics 2017g) have been used for this apportioning task. An alternative contemporary population projection that could be used in lieu of the census is to use the NSW Department of Planning Projections (NSW Department of Planning and Environment 2017). Given the timing of the release of the 2016 Census results in 2017 concurrent with the timing of this thesis, the 2016 ABS Census has been used.

Of the 91 NSW SA3s, 88 were used in the study as 3 found to have extremely low population numbers (two had less than 10 people and one had less than 400). These SA3s were also missing input data to support the DEA. These were excluded. The excluded SA3s by code and name are as follows:

- 12402 Blue Mountains – South (population less than 10 individuals);
- 10702 Illawarra Catchment Reserve (population less than 10 individuals); and
- 10803 Lord Howe Island (inconsistent and very low PBS data and population of 382).

According to the 2016 Census, the 88 SA3s used in the study have populations ranging from 12,737 in the Lower Murray Area of Murrumbidgee LHN, to 230,326 in the Sydney Inner City Area which straddles South Eastern Sydney and Sydney LHNs (Australian Bureau of Statistics 2017g). Table 8 (page 140) shows a summary of the 88 NSW SA3s of the study and their proportional population mapping to build up the 15 NSW LHNs. Equation 13 outlines the mapping employed to apportion the SA3 populations to LHNs. An almost identical method of apportioning LGAs to SLAs and NSW LHNs and former NSW AHSs was used with the former NSW RDF and EHUIs (Marshall & Slater 2015).

Table 8 88 DMUs (NSW SA3 populations) used in DEA with population portions of each LHN

DMUs (SA3 Code and Name)	LHN	Pop share of SA3 in each LHN 2016 Census	SA3 Pop 2016 Census
10601 Lower Hunter	Hunter New England	100.00%	89,621
10602 Maitland		100.00%	76,134
10603 Port Stephens		100.00%	73,036
10604 Upper Hunter		100.00%	30,877
10801 Great Lakes		100.00%	31,895
10802 Kempsey - Nambucca		0.12%	49,005
10804 Port Macquarie		0.02%	79,929
10805 Taree - Gloucester		100.00%	54,761
11001 Armidale		100.00%	38,098
11002 Inverell - Tenterfield		100.00%	38,858
11003 Moree - Narrabri		100.00%	26,452
11004 Tamworth - Gunnedah		100.00%	82,379
11101 Lake Macquarie - East		100.00%	123,536
11102 Lake Macquarie - West		100.00%	77,075
11103 Newcastle		100.00%	169,571
10104 South Coast	Illawarra Shoalhaven	0.28%	72,073
10701 Dapto - Port Kembla		100.00%	77,934
10703 Kiama - Shellharbour		100.00%	92,470
10704 Wollongong		99.98%	133,292
11401 Shoalhaven		100.00%	101,617
11402 Southern Highlands		0.15%	49,059
10402 Coffs Harbour	Mid North Coast	99.48%	87,943
10802 Kempsey - Nambucca		99.88%	49,005
10804 Port Macquarie		99.98%	79,929
10101 Goulburn – Yass	Murrumbidgee	26.89%	73,003
10302 Lachlan Valley		10.61%	56,416
10901 Albury		100.00%	62,504
10902 Lower Murray		28.76%	12,737
10903 Upper Murray exc. Albury		100.00%	42,542
11301 Griffith - Murrumbidgee (West)		100.00%	49,464
11302 Tumut - Tumbarumba		99.99%	14,686
11303 Wagga Wagga		100.00%	95,644
10301 Bathurst	Nepean Blue Mountains	0.04%	47,783
10303 Lithgow - Mudgee		45.88%	47,572
11502 Dural - Wisemans Ferry		0.34%	27,076
11503 Hawkesbury		100.00%	25,165
11504 Rouse Hill - McGraths Hill		31.65%	34,081
12401 Blue Mountains		100.00%	78,496
12403 Penrith		95.28%	143,452
12404 Richmond - Windsor		100.00%	37,469
12405 St Marys		100.00%	55,427
12702 Fairfield		0.94%	193,076
10401 Clarence Valley	Northern NSW	100.00%	50,961
10402 Coffs Harbour		0.52%	87,943
11201 Richmond Valley - Coastal		100.00%	80,412
11202 Richmond Valley - Hinterland		100.00%	71,294
11203 Tweed Valley		100.00%	93,458
11501 Baulkham Hills	Northern Sydney	18.43%	148,761
11502 Dural - Wisemans Ferry		49.02%	27,076
12101 Chatswood - Lane Cove		100.00%	117,824
12102 Hornsby		100.00%	83,456
12103 Ku-ring-gai		100.00%	123,474
12104 North Sydney - Mosman		100.00%	100,152
12201 Manly		100.00%	44,994
12202 Pittwater		100.00%	63,504
12203 Warringah		100.00%	157,846
12502 Carlingford		10.45%	68,864
12601 Pennant Hills - Epping		84.39%	49,288
12602 Ryde - Hunters Hill		97.49%	140,873

DMUs (SA3 Code and Name)	LHN	Pop share of SA3 in each LHN 2016 Census	SA3 Pop 2016 Census
11701 Botany	South Eastern Sydney	100.00%	49,169
11702 Marrickville - Sydenham - Petersham		0.04%	57,574
11703 Sydney Inner City		94.36%	230,326
11801 Eastern Suburbs - North		100.00%	136,152
11802 Eastern Suburbs - South		100.00%	149,266
11903 Hurstville		93.89%	132,733
11904 Kogarah - Rockdale		100.00%	145,493
12703 Liverpool		0.57%	122,238
12801 Cronulla - Miranda - Caringbah		100.00%	114,106
12802 Sutherland - Menai - Heathcote		100.00%	111,321
10704 Wollongong	South Western Sydney	0.02%	133,292
11402 Southern Highlands		99.85%	49,059
11901 Bankstown		99.09%	178,409
11902 Canterbury		5.84%	141,819
12301 Camden		100.00%	64,212
12302 Campbelltown (NSW)		100.00%	162,845
12303 Wollondilly		100.00%	42,215
12403 Penrith		4.72%	143,452
12501 Auburn		0.91%	94,077
12503 Merrylands - Guildford		22.72%	157,512
12701 Bringelly - Green Valley		100.00%	106,378
12702 Fairfield		99.06%	193,076
12703 Liverpool		99.43%	122,238
10101 Goulburn – Yass	Southern NSW	73.11%	73,003
10102 Queanbeyan		100.00%	59,472
10103 Snowy Mountains		100.00%	19,740
10104 South Coast		99.72%	72,073
11302 Tumut - Tumbarumba		0.01%	14,686
11702 Marrickville - Sydenham - Petersham	Sydney	99.96%	57,574
11703 Sydney Inner City		5.64%	230,326
11901 Bankstown		0.91%	178,409
11902 Canterbury		94.16%	141,819
11903 Hurstville		6.11%	132,733
12001 Canada Bay		100.00%	89,595
12002 Leichhardt		100.00%	59,540
12003 Strathfield - Burwood - Ashfield		100.00%	159,133
10301 Bathurst	Western NSW	99.96%	47,783
10302 Lachlan Valley		89.39%	56,416
10303 Lithgow - Mudgee		54.12%	47,572
10304 Orange		100.00%	58,991
10501 Bourke - Cobar - Coonamble		100.00%	25,059
10503 Dubbo		100.00%	71,138
11501 Baulkham Hills	Western Sydney	81.57%	148,761
11502 Dural - Wisemans Ferry		50.64%	27,076
11504 Rouse Hill - McGraths Hill		68.35%	34,081
11601 Blacktown		100.00%	139,391
11602 Blacktown - North		100.00%	95,745
11603 Mount Druitt		100.00%	115,220
12501 Auburn		99.09%	94,077
12502 Carlingford		89.55%	68,864
12503 Merrylands - Guildford		77.28%	157,512
12504 Parramatta		100.00%	146,708
12601 Pennant Hills - Epping		15.61%	49,288
12602 Ryde - Hunters Hill		2.51%	140,873
10201 Gosford	Central Coast	100.00%	173,257
10202 Wyong		100.00%	162,052
10502 Broken Hill and Far West	Far West	100.00%	20,598
10902 Lower Murray		71.24%	12,737
Average SA3 pop size of the 88 SA3s			87,942
Median SA3 pop size of the 88 SA3s			78,215
Minimum SA3 pop size			12,737
Maximum SA3 pop size			230,326

Sources: (Australian Bureau of Statistics 2001, 2012, 2016d, 2017g; SLHD Planning Unit 2013).

Equation 13 – Apportioning / mapping SA3 populations to NSW LHNs

$$LHN_n = \sum_{i=1}^{n} (SA3\ pop_i)\ x\ \ (\%\ SA3\ pop_i in\ LHN_n)$$

Where: $SA3\ pop_i = SA3\ popultion_i\ size\ in\ LHN_n$

$\%\ SA3\ pop_i in\ LHN_n = portion\ of\ SA3\ pop_i\ in\ the\ LHN$

5.3 DEA DATA

As a relative concept DEA does not require all of the outputs and inputs of DMUs, requiring only a sensible choice of variables that express the performance of DMUs (Morita & Avkiran 2009, p. 164; Sherman & Zhu 2006b). Contextually for the HORSt, the financial inputs identified in the literature review (MBS expenditure, PBS expenditure, state public hospitals expenditure) that represent the majority of taxpayer funding inputs across the continuum of care, around 73% in 2015-16 (Australian Institute of Health and Welfare 2017a), are a sensible choice for inclusion in the DEA. All are available at the SA3 population level.

The governance review in Chapter Three also identified that out-of-pocket patient costs for non-hospital Medicare subsidised services are now available for SA3 populations. Whilst this data could be used as a financial input in the DEA, a decision was made not to do so on the basis that of the literature presented surrounding the fact that out-of-pocket costs represent health inequity; where people forgo or delay access to private treatment due to unaffordability of costs and run the risk of worsening their health. As such out-of-pocket cost will be more appropriately considered for inclusion in the HORSt as a predictor variable in the HORSt regression. Furthermore, given the widespread variations in out-of-pocket costs which are determined by private doctors' profit-making motives, it is difficult to understand the resource contribution that out-of-pocket costs make to the production of health outcomes across the continuum of care. This is especially so when out-of-pocket costs in acting as a barrier to private services:

- can lead to people to utilising higher costing taxpayer provided, free of charge services, in the public sector; or
- cause people to delay treatment exacerbating heath conditions leading to poorer health that may ultimately cost more to treat.

The outputs identified in the literature review, PPHs and Charlson Co-Morbidities can be used as proxies of population health outcomes via population health status. As such, the relative efficiency scores produced from an output orientated VRS DEA will reflect the appropriate mix of health services inputs to produce effective health outcomes (allocative efficiency). SA3 populations that are found to be relative allocative efficient (100%) compared to all other SA3s (the efficient peers) will establish the benchmark for the HORSt.

In keeping with the literature that underpins the use of prolonged high rates of PPHs amongst populations as hot spots of poor health / cold spots in the case of the HORSt to represent good health and in using PPHs as a proxy variable of population health status, the objective of the DEA for the HORSt is concerned with representing the typical relative efficiencies of each of the populations' health status. The work of Duckett and Griffiths (2016b, pp. 5-6) in defining hot spots using PPHs, which is not a DEA study, used a minimum persistence threshold of three years' data to identify a hotspots within 10 years data. It follows that if a similar methodology could be employed with HORSt using the available population data to identify prolonged good health status; a question arises of which years' measured frontier would represent the norm sufficient enough to inform resource distribution in any given year?

Given that there are resource limitations to this study pertaining to costs of purchased data required for the DEA inputs, limited to three successive years, a measure of central tendency of three years' output and inputs data will be used in the DEA to represent the typical output and resource usage of each DMU. The median or middle score is recognised in the literature as a useful measure of central tendency as it is stable and not distorted by any outliers (Manikandan 2011; Ott 1988, p. 39). As such the median of the data will be used. Doing so with the population data for the three years represents the measured median allocative efficiency scores for the DMUs and as discussed according to Coelli et al. (2005, p. 203) pertaining to the use of the whole populations' data this does not require bootstrapping. The individual years and the median data for the DEA outputs and inputs are tabled in the following sections. The data over the three years can be demonstrated to be very stable.

The goal of developing the HORSt in this study is to demonstrate a workable proof of concept model that answers the research questions and can inform resource distribution from state to LHNs and this is by no means compromised by utilising the methodology outlined herein that is constrained by practical limitations of the resources available. As discussed in section 4.5, the third stage of the

HORSt methodology requires a measure of the relative efficiencies of each DMU to the efficient DMUs. This can be entirely satisfied by the methodology above utilising the median population data.

5.3.1 DEA OUTPUT DATA

The two alternative measures identified in the literature to proxy population health outcomes via representing markers of population health status; PPHs and Charlson Co-morbidities are now examined in terms of their data sources for suitable inclusion in the study as the output variable in the DEA. Methodology for their extraction from NSW Health data sources are examined, along with quality assurance measures that can be applied. Standardising the variables for age and casemix complexity is also examined. Given that both variables represent a proxy of poor health status and the DEA model's linear programming is designed to consider maximising desirable outcomes, a methodology for translating the poor (undesirable) health status for use in the DEA computations is also examined.

5.3.1.1 DEA Outputs Data – Age-standardised and casemix adjusted PPHs

As discussed in the literature review there are 22 PPHs. Upon reviewing the ethics approval for this study, the SWSLHD Epidemiology accessed NSW hospital data from the NSW Secure Analytics for Population Health Research and Intelligence (SAPHaRI) data bases (Centre for Epidemiology and Evidence 2017). Prior to understanding that MBS and PBS expenditure data was only affordable for three years and the study therefore only utilised three years' worth of data, the data extracted from the NSW hospital data bases comprised ten years' of PPHs to 2016/17 using the identifying and definitional attributes of the 2016 National Healthcare Agreement: PI 18–Selected PPHs (Australian Institute of Health and Welfare 2017b), which is tabled in appendix 1. These attributes show how PPHs are identified within hospital data sets. These are classified by the National Health Care agreement across three broad categories, of Chronic, Acute and Vaccine Preventable. For the HORSt all three categories of PPHs are included so as to represent a broad level of population health status for each DMU.

The data extract from the NSW for PPHs was conducted for each hospital separation. A hospital separation is defined by the AIHW as the:

"process by which an episode of care for an admitted patient ceases. A separation may be formal or statistical. Formal separation: The administrative process by which a hospital records the cessation of treatment and/or care and/or accommodation of a patient. Statistical separation: The

administrative process by which a hospital records the cessation of an episode of care for a patient within the one hospital stay" (Australian Institute of Health and Welfare 2018f).

To represent the health status of each SA3 population, the separations data extracted were from the patient's demographic location of residence (their SA3 population), not the hospital in which they were treated. Data elements included in the extract for each separation included:

- diagnosis codes that support identification of the separation being an PPH;
- patient demographics;
    - SA3 location, gender, five-year age groups from 0-4, to 80-84 and 85 years and over; and
- resource intensity data;
    - Australian Refined Diagnosis Related Group (AR-DRG), National Weighted Activity Units (NWAU).

These data elements above support the data extraction to be expressed as an age-standardised rate adjusted for patient resource complexity, casemix.

According to the AIHW, age standardisation is:
"A method of adjusting the crude rate to eliminate the effect of differences in population age structures when comparing crude rates for different periods of time, different geographic areas and/or different population sub-groups (e.g. between one year and the next and/or States and Territories, Indigenous and non-Indigenous populations). Adjustments are usually undertaken for each of the comparison populations against a standard population (rather than adjusting one comparison population to resemble another). Sometimes a comparison population is referred to as a study population" (Australian Institute of Health and Welfare 2005).

Age standardisation can be taken a step further by including gender, in order to calculate an age gender standardised rate. Doing so allows for an adjustment to eliminate any effect on the difference in compared populations attributed to sex. The data extracted and ethics approval enables this age gender standardisation to occur and the underpinnings for including sex in the extraction in the planning phase for the study was somewhat guided by the developments of the former NSW RDF, which considered a segmented approach of specific health programs whereby the effects of sex were more pronounced on health needs such as obstetrics (Inter-Government & Funding Strategies 2005b). However, the AIHW (Australian Institute of Health and Welfare 2005) states that standardisations extended to include an adjustment for sex is usually not undertaken and congruent with the health program approach taken by the former NSW RDF done so only when the study outcome is specifically interested in sex specific affects as for example; considering rates of caesarean sections. Conversely the HORSt development in this study is to demonstrate a proof of concept model for resource distribution amongst whole populations and is not health program specific. As such, sex standardisation was not conducted. Further discussion on feasibility and limitations for refining the HORSt at the program level is included in Chapter Seven.

According to the Australian Institute of Health and Welfare (2005); Naing (2000), there are two established methods of age standardisation:

- a direct method which is generally used for comparisons between study groups; and
- an indirect method which is recommended when the age-specific rates for the population being studied are unknown

The method used for the HORSt employs the direct method, as the comparative rate between the study groups is sought and the entire populations' rates being studied are derived from the extract. The direct method is used also used by NSW Health for PPH separations with the rate expressed per 100,000 people (Epidemiology and Evidence 2017). The AIHW provides guidelines for the direct method shown below in equation 14:

Equation 14 - Direct Method of Standardisation

$$SR = \frac{\Sigma(ri \times Pi)}{\Sigma(Pi)}$$

Where:

SR = the age-standardised rate for the population being studied;

ri =the age-group specific rate for age group i in the population being studied;

Pi =the population of age group i in the standard population ; and*

$\Sigma(ri \times Pi) =$ *is the expected number of events in the population being studied*

(Australian Institute of Health and Welfare 2005).

* *"The ABS and AIHW recommend that the 30 June 2001 standard population should be used for age-standardisation until a new standard population becomes available after the 2026 Census"* (Australian Bureau of Statistics 2013).

PPHs differ between conditions and the patients presenting with these in hospitals can logically have different levels of complexity / severity and associated resource intensity even amongst the patients having the same PPHs. If PPHs were simply subject to age standardisation, the severity and resource intensity of the patients would not be represented in the data and comparison of population health status across populations so as to identify cold or hot spots may be distorted. A remedy for this situation is to use the casemix data contained within each separation's record, using the NWAU.

"An NWAU is a measure of health service activity expressed as a common unit. It provides a way of comparing and valuing each public hospital service (whether it is an admission, emergency department presentation or outpatient episode), by weighting it for its clinical complexity. The average hospital service is worth one NWAU – the most intensive and expensive activities are worth multiple NWAUs, the simplest and least expensive are worth fractions of an NWAU" (Administrator National Health Funding Pool 2018).

To support the inclusion of patient severity and resource intensity with the PPH data to be used in the DEA for the HORSt, the data extraction of separations was summarised by total NWAUs for each age group of each SA3 population. This data was then subjected to direct standardisation so as to derive an age-standardised casemix adjusted rate of PPHs for each SA3 (each DMU) per 10,000 people. The DEA output expressed as an age-standardised rate, along with DEA inputs, do not cause a problem for DEA with numerous examples in the literature expressed this way (Cordero et al. 2015; Liu et al. 2010).

The NSW Health Stats website publishes data on the volume and age adjusted rates of PPHs at the LHN level (Epidemiology and Evidence 2017) and the AIHW publishes PPHs the same data at the SA3 level (Australian Institute of Health and Welfare 2018a). These published data rates are not adjusted for patient severity and resource intensity as per the methodology for this study outlined above using NWAUs. In addition, the AIHW data shows a greater volume of separations compared to the NSW Health Stats published data and that extracted from the NSW Health data, with the AIHW data including PPHs occurring at private hospitals (Australian Institute of Health and Welfare 2018a)

Quality assurance checking of the data extract can be conducted by comparison to the officially published rates per 100,000 people and volumes of PPHs on the NSW Health Stats website. In order to do so, the data extract was summarised by total separations for each age group for each SA3 and the direct method of age standardisation (excluding an NWAU adjustment) was applied. The extracted data was then required to be mapped to the LHN level. To do so the PPH standardised rates apportioning used the same methodology of that in equation 13. This is shown as follows in equation 15.

Equation 15 – Apportioning / mapping SA3 standardised rates of PPHs to NSW LHNs

$$PPHs\ per\ 100k\ LHN_n = \sum_{i=1}^{n} (SA3\ ACSC\ rate\ per\ 100k_i\ in\ LHN_n)\ x\ (\%\ SA3\ pop_i in\ LHN_n)$$

Where:

$$SA3\ PPH\ rate\ per\ 100k_i\ in\ LHN_n = PPH\ rate\ per\ 100{,}000\ of\ SA3\ population\ _i\ in\ LHN_n$$

$$\%\ SA3\ pop_i in\ LHN_n = portion\ of\ SA3\ population_i\ in\ the\ LHN$$

There are some minor differences between the data extract and the official published figures. However, these are not manifestly different to warrant questioning the validity of the data extract for its use with this study, whereby the volume of separations in the extract compared with published figures are no more than 3% larger in any of the three years. Importantly the proportionality of the volume and size of the age-standardised rates amongst the LHNs are the same. Furthermore, there are several reasons that explain these differences. These are:

- the nature of the extract at SA3 level to support the HORSt analysis requires apportioning / mapping by SA3s to LHNs to allow the quality assurance comparison as per previously discussed, whereas the NSW Health Stats published data did not have to undergo this apportioning;
- the NSW Health Stats data *estimates* the NSW patients with PPHs receiving treatment interstate, whereas the extract *counts* the patient volume of these patients;
- the NSW Health Stats data excludes PPH separations that are categorised as rehabilitation, whereas the HORSt in wanting to capture a broad view of health status approximated by these separations does not exclude these separations; and
- the NSW Health Stats data for LHNs are point estimates bound by upper and lower confidence intervals with some very low counts of PPHs in some LHNs excluded, whereas the extract simply takes the volume of patient separations for PPHs and calculates an age-standardised rate

(Epidemiology and Evidence 2017).

The following graphs (figures 16 through 21) summarises differences between the extract and the NSW Health Stats published data, showing the very small differences between the data extract ages sex standardised rates and volumes of PPHs from 2013/14 through to 2015/16. With minor differences explainable, the quality assurance testing finds that the data extract is consistent with the official published figures. As such the extract PPHs data will be used with HORSt.

Figure 16 Comparison of PPHs extracted vs NSW Health published age-standardised rates for 2013/14

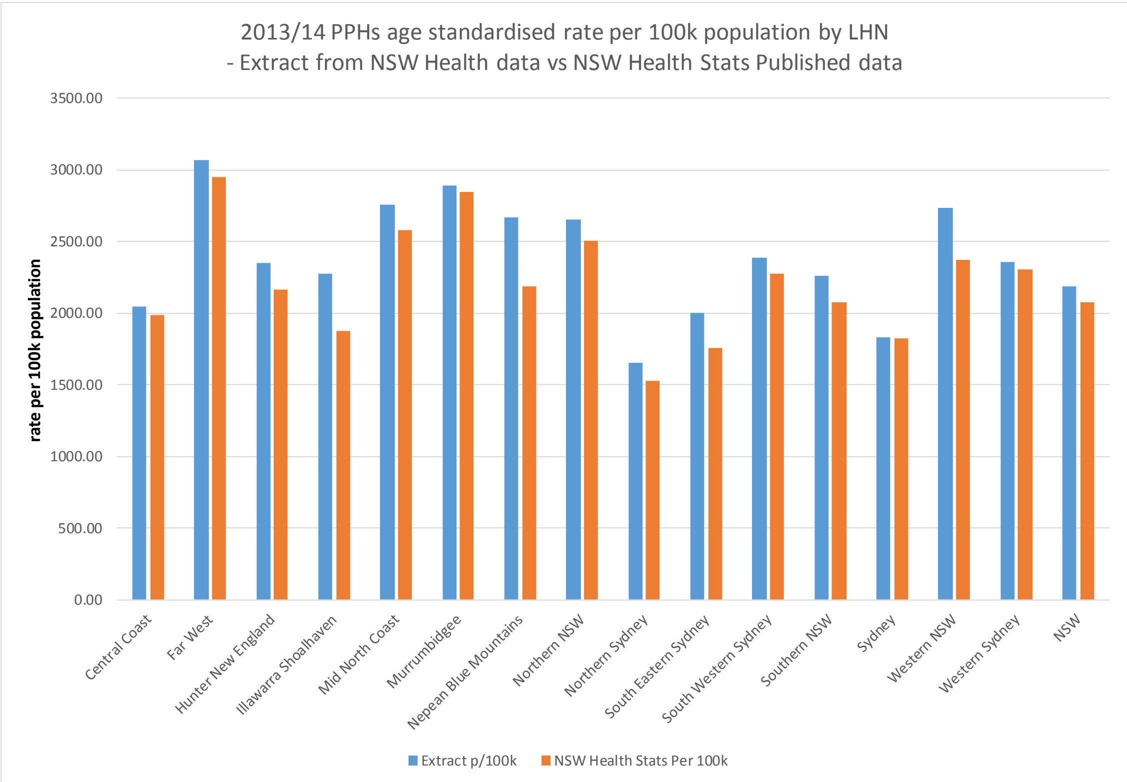


Figure 16: (Centre for Epidemiology and Evidence 2017; Epidemiology and Evidence 2017).

Figure 17 *Comparison of PPHs extracted vs NSW Health published volume of separations for 2013/14*

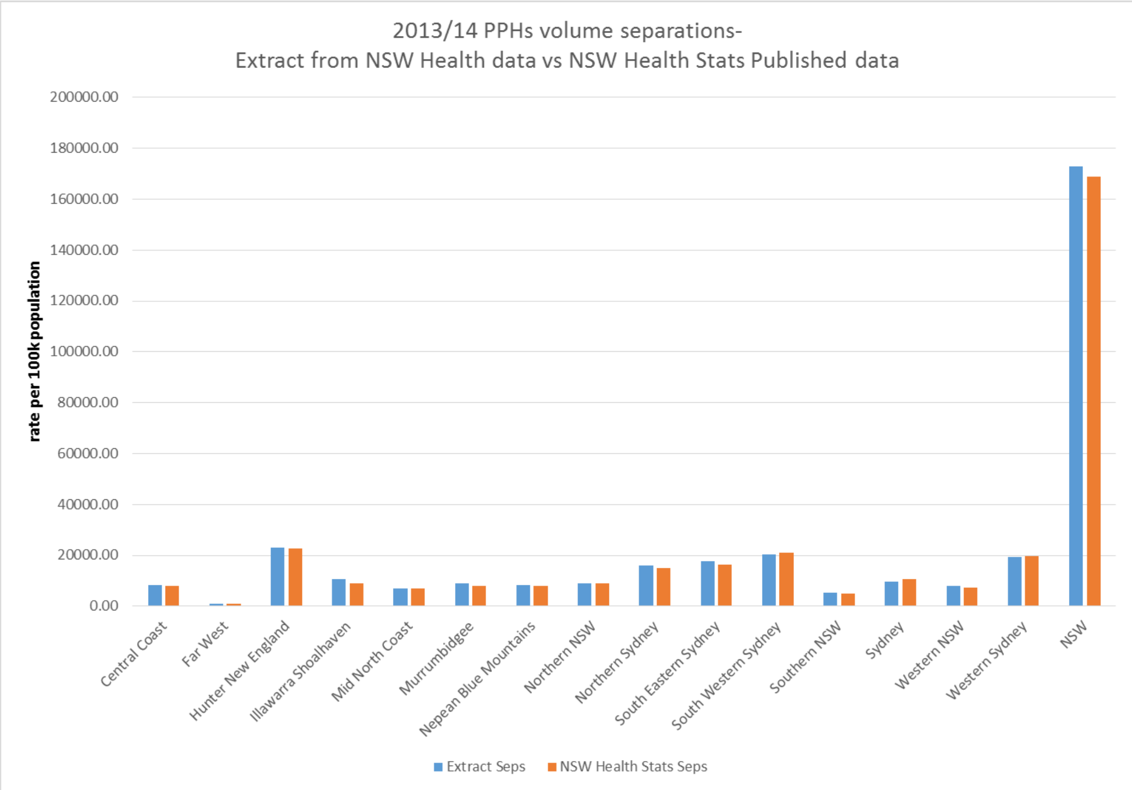


Figure 17: (Centre for Epidemiology and Evidence 2017; Epidemiology and Evidence 2017).

Figure 18 *Comparison of PPHs extracted vs NSW Health published age-standardised rates for 2014/15*

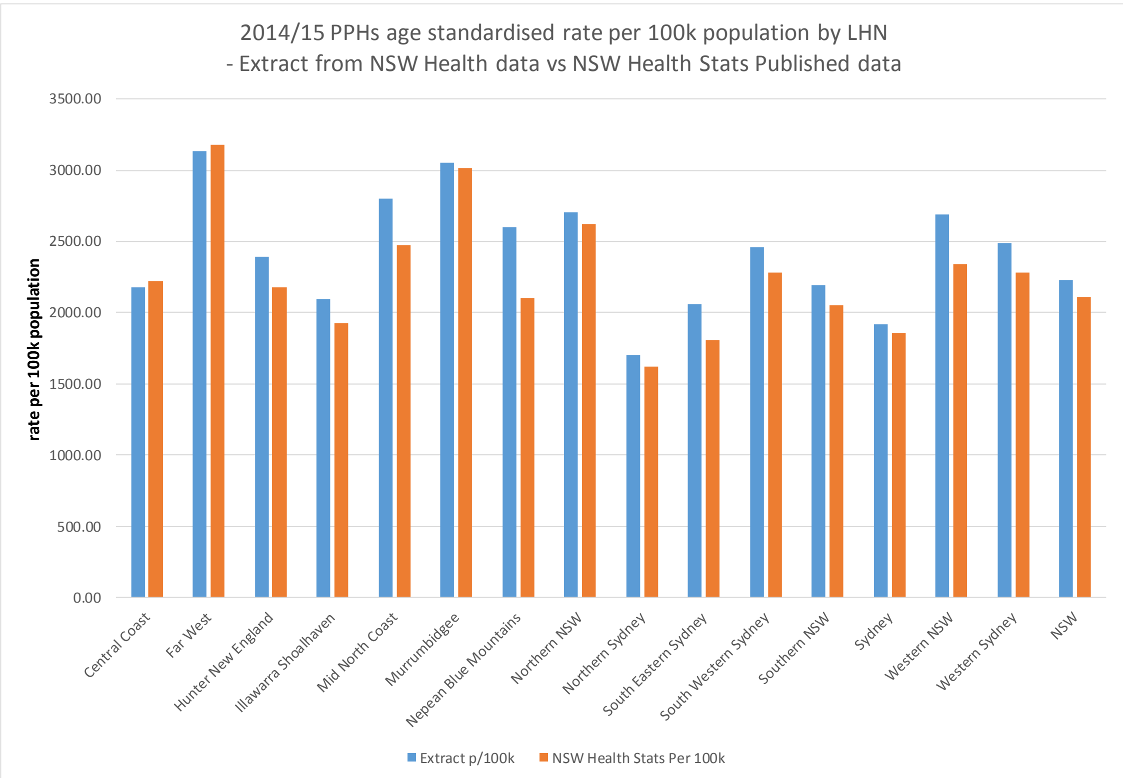


Figure 18 : (Centre for Epidemiology and Evidence 2017; Epidemiology and Evidence 2017).

Figure 19 *Comparison of PPHs extracted vs NSW Health published volume of separations for 2014/15*

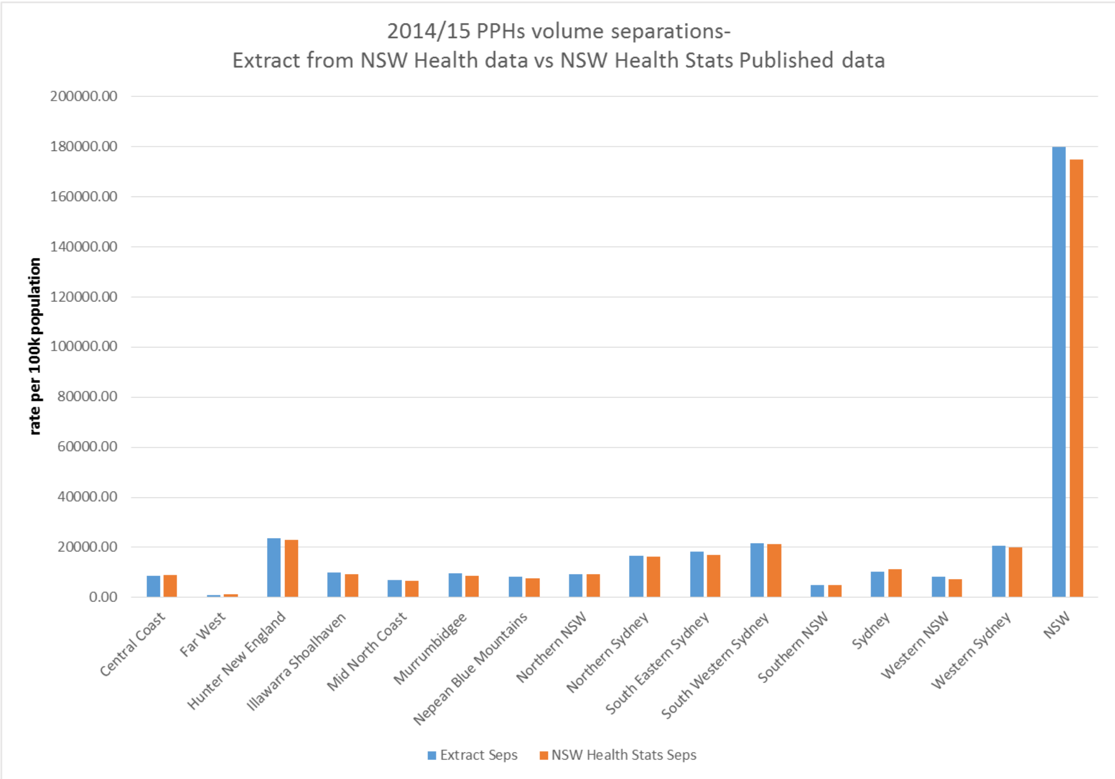


Figure 19: (Centre for Epidemiology and Evidence 2017; Epidemiology and Evidence 2017).

Figure 20 *Comparison of PPHs extracted vs NSW Health published age-standardised rates for 2015/16*

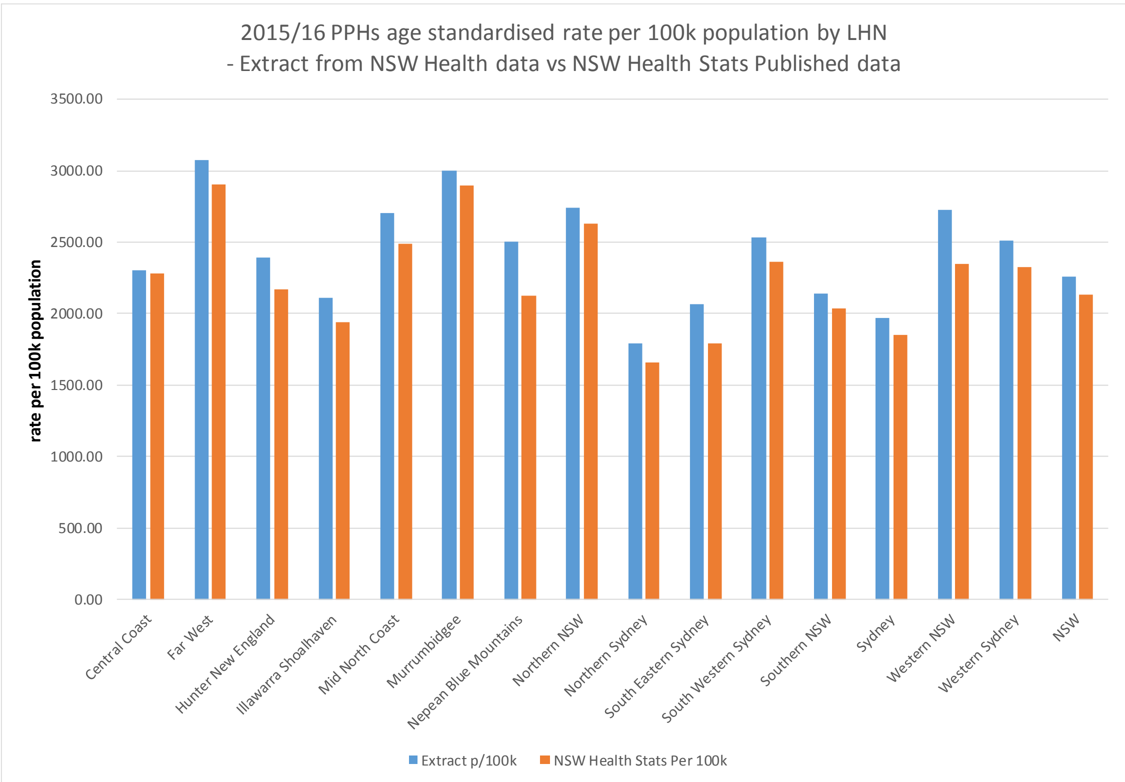


Figure 20: (Centre for Epidemiology and Evidence 2017; Epidemiology and Evidence 2017).

Figure 21 Comparison of PPHs extracted vs NSW Health published volume of separations for 2015/16

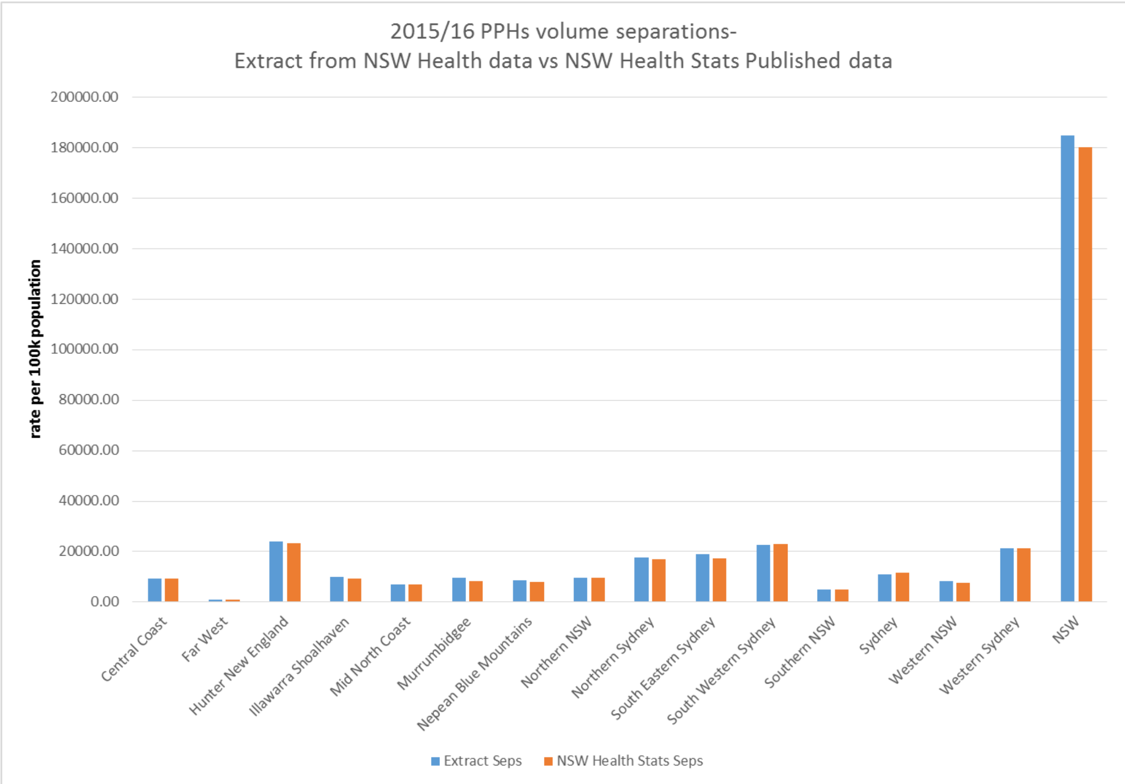


Figure 21: (Centre for Epidemiology and Evidence 2017; Epidemiology and Evidence 2017).

5.3.1.2 DEA Outputs Data Alternative – Age-standardised Charlson Co-morbidity

As an alternative to using the age and casemix adjusted rates of PPHs as the output variable in the HORSt DEA, guided by the literature review, Charlson Co-morbidities could be used as a proxy for each SA3's / DMU's population health status. The Charslon Co-morbities of each separation have a weighting assigned, a score, that can be used to reflect complexity of the patient and or the associated NWAU of the separation could also be used.

There is some overlap between Charlson Co-morbidties and the PPHs where some PPHs separations will also have a Charlson score and the Charlson Co-morbidity can be a predictor of PPHs (Eggli et al. 2014; Saver et al. 2014) Given that, the intent to use the Charlson Co-morbities as an alternative standalone proxy of health status in place of PPHs, there was no need for the Charlson Co-morbidties extract to exclude separations that also were found to be PPHs.

The data extract followed the literature of Sundararajan et al. (2004) which identified the Charlson Co-morbidities separations and assigned a score using secondary diagnosis codes in each separation.

A complete list of the codes is available in appendix 2, which uses the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM), (Australian Consortium for Classification Development 2018).

Similar to the extract of PPHs / PPHs, SWSLHD Epidemiology extracted the data from the NSW SAPHaRI data sets. However, the extracts were found upon inspection to be somewhat unreliable. Significant volumes of separations around 7% to 10% across each SA3 that should have had positive Charlson scores were found to have zero scores, with many of the ICD-10-AM codes found to have decimal place errors that were affecting the assignment of the scores. Due to these errors, the use of the Charlson Co-morbidities as an alternative to PPHs were considered to be unreliable for the purposes of this study and were not pursued further.

5.3.1.3 Transforming the DEA Outputs Data for use with the DEA

The HORSt DEA output in this model is expressed by age-standardised and case mix adjusted rates of PPHs per 10,000 people. Importantly in the context of the HORSt DEA the goal is to maximise outputs and, in this case, maximum health outcomes are approximated by health status represented by low rates of PPHs. This means that the PPHs need to be mathematically transformed as higher rates are bad and lower rates are desirable and, in the DEA, required to be maximised. In the DEA literature, outcomes that need this transformation are termed undesirable outcomes and similarly inputs requiring transformation are called undesirable inputs (Aminuddin et al. 2017; Liu et al. 2010; Valdmanis et al. 2008).

The literature has multiple methods for transforming undesirable variables for use in DEA. A critique of the literature by Liu et al. (2010, p. 178) examine the three main established published peer reviewed methodologies and concluded that the type of transformation applied is very much a matter of the context of the individual study. With respect to this, the operationalisation of the HORSt and the study's resources, the key requirements for the treatment of the undesirable output for the HORSt is that the method:

- does not overly complicate the interpretation of the DEA objectives as a meaningful benchmark as outlined in the previous chapter (page 122);
- does not alter the ranking and identification of efficient and inefficient DMUs; and
- from a practical point of resourcing for this study, allows transformed variables to be calculated using the purchased DEA software for this study, namely PIM-DEA and Frontier Analyst.

A critique of the transformation methodologies is outlined in equations 16 through 18. These are examined along with a non-transformation methodology for the HORSt output data. The methodology to be used for the study is then justified and outlined in equation 18, with an example shown in equation 19. The transformed data for each DMU is then presented in Table 9 and the distribution of the transformed results is presented in Figure 26.

Equation 16 – Additive inverse for transforming undesirable DEA variables

$$f\ (U\ )\ =\ -U$$

Where U = the data to be transformed

Equation 16 demonstrates the approach by Koopmans (1951, p. 35). This simply transforms the undesirable output by adding a negative sign to the data to be transformed, an additive inverse approach. The simplicity of this approach is that it maintains the absolute differences between the DMUs' data that is transformed. However, the transformed data becomes negative. Liu et al. (2010, p. 178) and Sarkis (2002, p. 119) argues that whilst negative data can be used it is problematic and very complicated in the computation of efficiency scores. Moreover a number of DEA software packages, PIM-DEA and Frontier Analyst for example, cannot handle negative data (Avkiran 2002, p. 11; Emrouznejad & Thanassoulis 2011; Hollingsworth 1997). For these reasons, this methodology was rejected for use with the HORSt DEA undesirable output.

Equation 17 – Multiplicative transverse for transforming undesirable DEA variables

$$f\ (U\ )\ =\ 1/U$$

Where U = the data to be transformed

The approach outlined in equation 17 involves taking the multiplicative inverse of the data (Francisco et al. 2012; Golany & Roll 1989, p. 241; Knox Lovell et al. 1995, p. 510). This avoids the conversion of the variable to negative numbers. However, in doing so it converts the data to a fractional number. Doing so is problematic as it does not preserve the absolute differences between the values of the DMUs' variables as it is a nonlinear transformation. This does not preserve the linearity and convexity of the DEA frontier (its overall shape as depicted by example in Figure 12 (page 121) and the approach has been therefore criticised as to its effects on the resulting efficiency scores of the DMUs (Liu et al. 2010, p. 178). For these reasons, this methodology was rejected for use with the HORSt DEA undesirable output.

Liu et al. (2010) also highlights that the treatment of undesirable DEA variables could remain untransformed where undesirable outputs could be simply treated as desirable inputs and vice versa thus reversing the ratio studied. For the HORSt, experiments were conducted with PIM-DEA software and Frontier Analyst software for swapping the undesirable output to be treated as a desirable input and vice versa with the DEA inputs now treated as outputs. Problematically, both the software products produced results that were difficult to interpret whereby some of the worst and best performing DMUs in terms of low and high ages standardised PPHs were found to be 100% efficient peers to each other, regardless of the resources (treated as an output) they consumed. The spread of efficiency scores made very little intuitive sense with all DMUs scores clustered within 10% of each other. Furthermore, both the software packages using identical data produced vastly different results for the same DMUs. As such this methodology was not pursued further.

As Cordero et al. (2015, p. 238) points out the problems encountered with swapping inputs and outputs are not surprising as:

"this method does not truly reflect the real production process and the scale and intervals of original variables are affected by the data transformation".

Furthermore, as Liu and Sharp (1999) outline, the nature of the output-input relationship and the DEA's model orientation is altered. The explanation of this reversal of outputs and inputs somewhat overcomplicates the parsimonious approach of the already defined scope for the HORSt DEA being an output orientated model (page 120). Therefore, this transformation methodology was rejected for use with the HORSt DEA undesirable output.

Equation 18 –Translational linear decreasing monotone approach for transforming undesirable DEA variables

$$f\,(U\,) = \,-U + k$$

Where U = the data to be transformed

k = a positive integer greater than the highest value of the undesirable variable to be transformed (Cordero et al. 2015, p. 238; Seiford & Zhu 2002, p. 18)

According to Liu et al. (2010) review, the approach shown in equation 18 has become widely used, with most literature using this method citing Seiford and Zhu's (2002) examination of this method. The work of Seiford and Zhu (2002) built on that of Ali and Seiford (1990), demonstrates through experimentation of multiple DEA transformations that this process maintains the linearity and convexity of the frontier, the rankings of efficiencies scores between DMUs and the identification of efficient and inefficient DMUs. Setting the size of k however just above the maximum value of the output variable does have an effect of the corresponding DMU's efficiency score, with a very low DEA score expected.

Similar to the transformation required for the HORSt using age-standardised rates of PPHs, Cordero et al. (2015) used this approach with age-standardised rates of ACSCs as an output to be minimised so as to act as a proxy of maximising health outcomes. The paper showed the area with the highest age-standardised rate of ACSCs was 474.22 per 10,000 people. This study set the size of $k = 500$ and did not explain the rationale for this. The lead author was e-mailed on 11 June 2018, seeking clarification as to whether k had been set as the nearest hundred up from the maximum rate of ACSCs per 10,000 people, as this seemed logical. An e-mail confirmation (appendix 5 page 295) was received on 12 June 2018 that this was indeed the case, with the maximum rate not used to avoid having a DMU with a zero value (Cordero 2018).

This method will be utilised for the HORSt. In summary justification for doing so is based on:

- the literature's finding of stability of this method to preserve the DMU efficiency rankings and the linearity and convexity of the DEA frontier;
- an example in peer reviewed literature of the transformation of the same output statistic (age-standardised rates of ACSCs / PPHs);
- there being no required change in the justified output orientated DEA model to support the HORSt; and
- there being no DEA software problems with the transformed results.

Specifically drawing upon the work of Cordero et al. (2015) in setting the size of k, with respect to age-standardised PPHs as the nearest hundred above the maximum rate, an examination of the median of the three years age-standardised PPH rates found that the highest DMU rate was 550 per 10,000 people. The next hundred up from this is 600. For the HORSt k was therefore set at 600. The output data was transformed accordingly using equation 18 and this value. The transformed

DEA output represents a desirable output, a proxy of the health status of each DMU whereby higher rates are desirable, transformed from the lowest rates of age-standardised PPH and vice versa.

Table 9 (page 157) shows a summary of the transformed DEA outputs data to be used in the study. The table shows that the median rate of PPHs for each SA3 population (DMU) compared to the individual years are a good measure of the populations' normal rate of PPHs with very little variation over the years. The highest median rate of PPHs, expressed as age-standardised NWAUs per 10,000 people was for the SA3 ***'10501 Bourke – Cobar –Coonamble' with 550.10.*** Using equation 18 where $(k) = 600$, the transformed value of this 49.90, as equation 19.

Equation 19 – PPHs - Transformed example for SA3 '10501 Bourke – Cobar –Coonamble'

$$f\ (U\ ) = \ -550.10 + 600 = 49.9$$

Similarly, the SA3 with the best median rate of PPHs NWAUs per 10,000 people is that of ***'12103 Ku-ring-gai'* with 149.15**, transformed to 450.85.

Both these rates reasonably reflect the extremes of health outcomes via population health status. The Bourke – Cobar – Coonamble area is remote and there is little access to services. The area has a higher at need indigenous population. The area is typified by very poor socioeconomic status, social determinants that give rise to very poor health outcomes. The Ku-ring-gai area is at the opposite end of the scale to these attributes (Centre for Epidemiology and Evidence 2018; Centre for Epidemiology and Research 2010; Western NSW Local Health District & Western NSW Medicare Local 2013).

Figure 22 (page 159) shows comparison histograms of the frequency of the median rates of PPHs (NWAUs) per 10,000 people and that of the transformed data for use as the DEA output. Figure 23 (page 159) shows each of the three years' rates of PPHs (NWAUs) per 10,000 people, showing little difference in the rates over time. Nonetheless, as per the statistical literature (Manikandan 2011; Ott 1988, p. 39) the use of the median is a sensible choice to be representative of the DMUs three years data in the analysis and be transformed as a desirable output in the HORSt DEA.

Table 9 Summary of Transformed age-standardised and casemix adjusted PPHs data to be used as the output data in the HORSt DEA

SA3 Code &Name	age standardised per 10,000 people				
	2013-14 ALL PPHs NWAUs	2014-15 ALL PPHs NWAUs	2015-16 ALL PPHs NWAUS	Median PPHs (NWAUs)	Median Transformed PPHs (NWAUs)
10101 Goulburn – Yass	285.35	285.35	303.86	285.35	314.65
10102 Queanbeyan	194.02	192.69	194.02	194.02	405.98
10103 Snowy Mountains	154.96	182.42	150.86	154.96	445.04
10104 South Coast	267.40	296.07	267.40	267.40	332.60
10201 Gosford	199.95	199.95	231.05	199.95	400.05
10202 Wyong	256.57	256.57	272.66	256.57	343.43
10301 Bathurst	179.28	179.28	251.57	179.28	420.72
10302 Lachlan Valley	285.37	287.04	285.37	285.37	314.63
10303 Lithgow - Mudgee	229.43	229.43	240.59	229.43	370.57
10304 Orange	243.69	243.69	289.68	243.69	356.31
10401 Clarence Valley	312.79	322.08	312.79	312.79	287.21
10402 Coffs Harbour	281.66	281.66	296.15	281.66	318.34
10501 Bourke - Cobar - Coonamble	**550.10**	**550.10**	**579.00**	**550.10**	**49.90**
10502 Broken Hill and Far West	289.41	272.73	289.41	289.41	310.59
10503 Dubbo	295.60	295.60	304.21	295.60	304.40
10601 Lower Hunter	267.29	273.53	267.29	267.29	332.71
10602 Maitland	278.24	289.34	278.24	278.24	321.76
10603 Port Stephens	212.75	212.75	241.63	212.75	387.25
10604 Upper Hunter	270.12	270.12	329.54	270.12	329.88
10701 Dapto - Port Kembla	315.31	315.31	348.52	315.31	284.69
10703 Kiama - Shellharbour	266.81	266.81	271.40	266.81	333.19
10704 Wollongong	262.01	264.91	262.01	262.01	337.99
10801 Great Lakes	217.75	258.02	217.75	217.75	382.25
10802 Kempsey - Nambucca	349.14	349.14	436.35	349.14	250.86
10804 Port Macquarie	231.51	231.51	231.65	231.51	368.49
10805 Taree - Gloucester	247.18	244.37	257.92	247.18	352.82
10901 Albury	232.45	255.67	232.45	232.45	367.55
10902 Lower Murray	278.86	281.60	278.86	278.86	321.14
10903 Upper Murray exc. Albury	261.43	266.99	261.43	261.43	338.57
11001 Armidale	219.17	219.17	236.55	219.17	380.83
11002 Inverell - Tenterfield	284.29	284.29	305.84	284.29	315.71
11003 Moree - Narrabri	282.33	282.33	351.82	282.33	317.67
11004 Tamworth - Gunnedah	298.14	298.14	354.25	298.14	301.86
11101 Lake Macquarie - East	200.29	200.29	208.03	200.29	399.71
11102 Lake Macquarie - West	231.06	231.06	235.52	231.06	368.94
11103 Newcastle	248.29	248.29	252.30	248.29	351.71
11201 Richmond Valley - Coastal	181.07	181.07	185.00	181.07	418.93
11202 Richmond Valley - Hinterland	282.11	282.11	305.51	282.11	317.89
11203 Tweed Valley	215.62	215.62	230.99	215.62	384.38
11301 Griffith - Murrumbidgee (West)	323.11	323.11	342.68	323.11	276.89
11302 Tumut - Tumbarumba	326.81	326.81	368.41	326.81	273.19
11303 Wagga Wagga	317.84	317.84	335.67	317.84	282.16
11401 Shoalhaven	259.83	259.83	295.35	259.83	340.17
11402 Southern Highlands	187.03	191.92	187.03	187.03	412.97
11501 Baulkham Hills	160.90	160.90	173.34	160.90	439.10
11502 Dural - Wisemans Ferry	165.76	220.39	165.76	165.76	434.24
11503 Hawkesbury	209.54	284.94	189.42	209.54	390.46

Table 9 continues on next page

Table 9 continued

SA3 Code & Name	2013-14 ALL PPHs NWAUs	2014-15 ALL PPHs NWAUs	2015-16 ALL PPHs NWAUS	Median PPHs (NWAUs)	Median Transformed PPHs (NWAUs)
	age standardised per 10,000 people				
11504 Rouse Hill - McGraths Hill	200.62	200.62	201.22	200.62	399.38
11601 Blacktown	321.79	321.79	364.72	321.79	278.21
11602 Blacktown - North	234.71	253.89	218.45	234.71	365.29
11603 Mount Druitt	532.18	532.96	532.18	532.18	67.82
11701 Botany	242.69	242.69	278.85	242.69	357.31
Petersham	253.90	252.83	288.12	253.90	346.10
11703 Sydney Inner City	289.00	297.28	289.00	289.00	311.00
11801 Eastern Suburbs - North	192.59	192.59	208.86	192.59	407.41
11802 Eastern Suburbs - South	216.42	216.42	244.11	216.42	383.58
11901 Bankstown	267.86	285.26	267.86	267.86	332.14
11902 Canterbury	281.43	281.43	308.15	281.43	318.57
11903 Hurstville	208.46	219.43	208.46	208.46	391.54
11904 Kogarah - Rockdale	235.36	246.00	235.36	235.36	364.64
12001 Canada Bay	170.88	170.88	182.41	170.88	429.12
12002 Leichhardt	211.39	211.39	221.23	211.39	388.61
12003 Strathfield - Burwood - Ashfield	205.30	205.30	222.85	205.30	394.70
12101 Chatswood - Lane Cove	164.07	164.07	192.34	164.07	435.93
12102 Hornsby	176.32	176.32	189.16	176.32	423.68
12103 Ku-ring-gai	**149.15**	**153.30**	**149.15**	**149.15**	**450.85**
12104 North Sydney - Mosman	186.13	204.57	186.13	186.13	413.87
12201 Manly	175.34	205.91	175.34	175.34	424.66
12202 Pittwater	154.74	154.74	189.23	154.74	445.26
12203 Warringah	177.42	177.42	190.62	177.42	422.58
12301 Camden	196.60	219.88	196.60	196.60	403.40
12302 Campbelltown (NSW)	317.51	317.51	334.24	317.51	282.49
12303 Wollondilly	198.81	198.81	221.72	198.81	401.19
12401 Blue Mountains	217.45	217.45	218.80	217.45	382.55
12403 Penrith	259.59	242.53	285.57	259.59	340.41
12404 Richmond - Windsor	390.92	407.33	390.92	390.92	209.08
12405 St Marys	326.84	359.27	326.84	326.84	273.16
12501 Auburn	270.11	273.55	270.11	270.11	329.89
12502 Carlingford	210.72	210.72	253.27	210.72	389.28
12503 Merrylands - Guildford	303.01	303.01	335.16	303.01	296.99
12504 Parramatta	267.73	267.73	283.96	267.73	332.27
12601 Pennant Hills - Epping	153.91	153.91	154.91	153.91	446.09
12602 Ryde - Hunters Hill	186.45	186.45	199.98	186.45	413.55
12701 Bringelly - Green Valley	255.74	255.74	286.49	255.74	344.26
12702 Fairfield	257.73	257.73	272.78	257.73	342.27
12703 Liverpool	292.75	292.75	334.98	292.75	307.25
12801 Cronulla - Miranda - Caringbah	166.26	166.26	210.16	166.26	433.74
12802 Sutherland - Menai - Heathcote	189.14	189.14	220.77	189.14	410.86
Maximum	**550.10**	**550.10**	**579.00**	**550.10**	**450.85**
Minimum	**149.15**	**153.30**	**149.15**	**149.15**	**49.90**
Mean	247.94	253.07	264.18	247.94	352.06
Median	245.44	253.36	259.67	245.44	354.56
SD	69.03	68.51	74.38	69.03	69.03

Figure 22 Histograms of the median rate of PPHs standardised for age and casemix and the Transformed output variable for use in the HORSt DEA

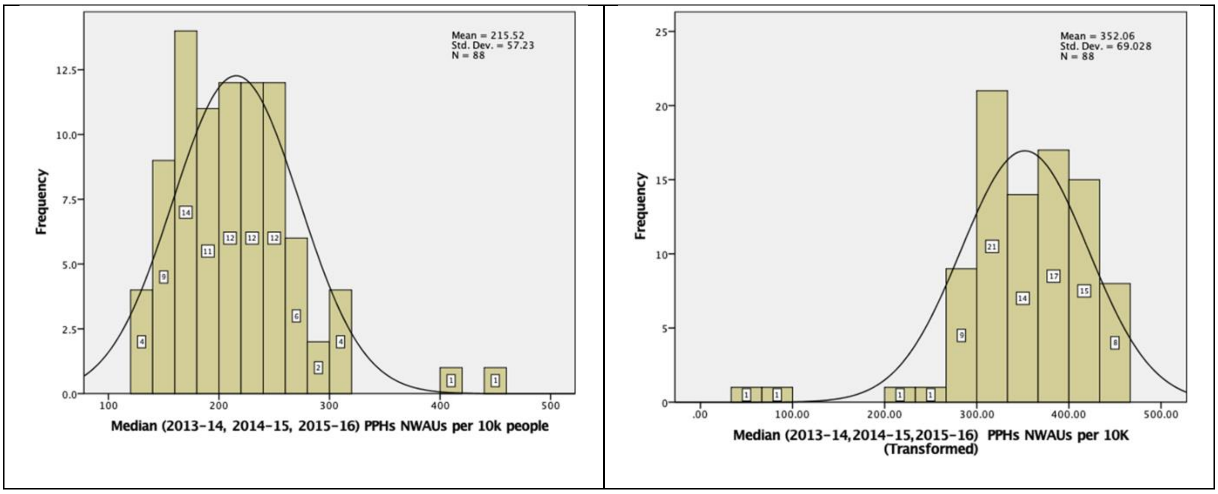


Figure 22 Histograms derived using SPSS software V24 (IBM Corp 2017).

Figure 23 Histograms of the 2013-14, 2014-15, 2015-16 rate of PPHs standardised for age and casemix

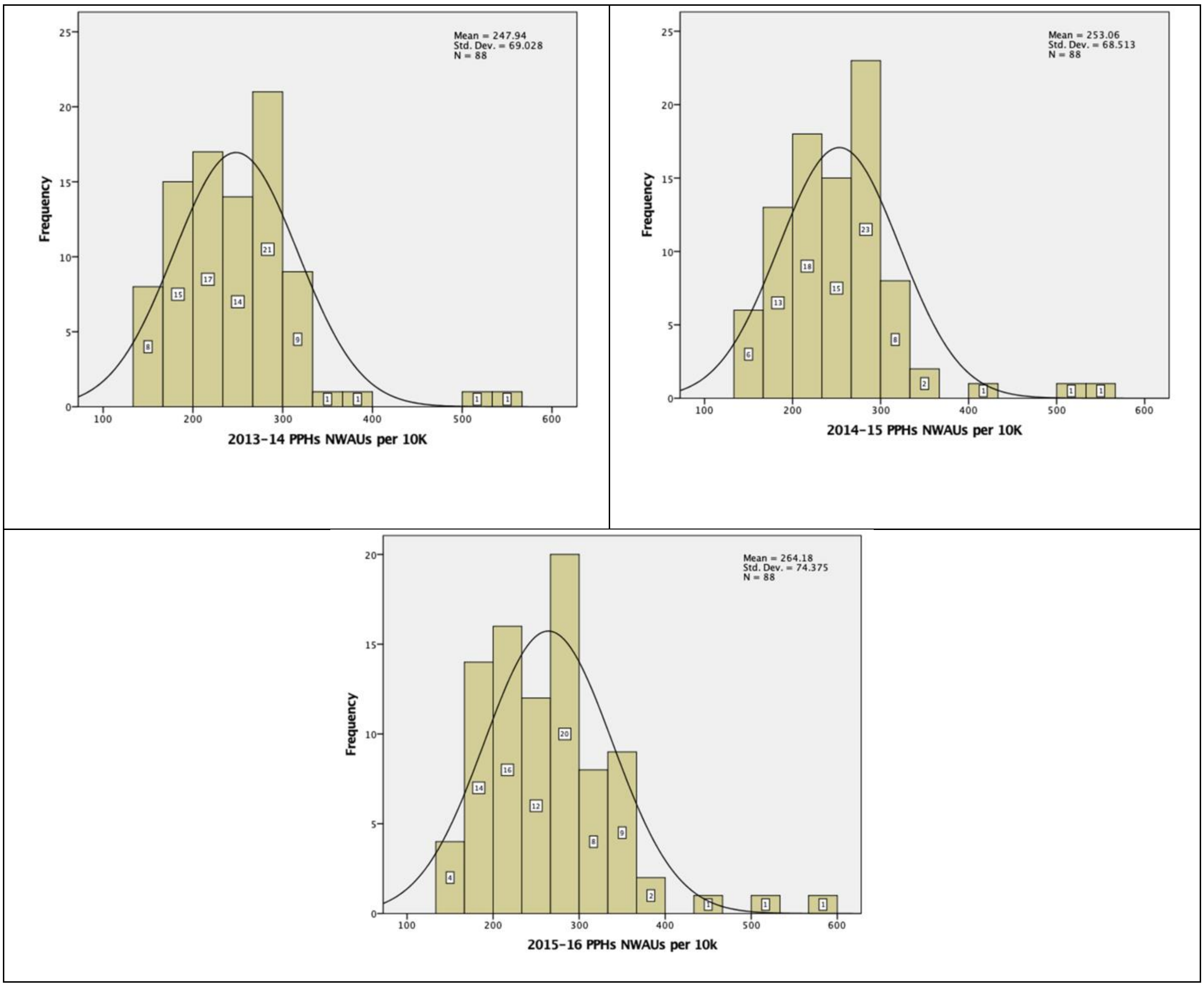


Figure 23 Histograms derived using SPSS software V24 (IBM Corp 2017)

5.3.2 DEA INPUTS DATA

As discussed, the DEA inputs represent the primary sources of taxpayer funded expenditure across the continuum of care. There are three DEA inputs being,

1. MBS expenditure for all residents of NSW;
2. PBS expenditure for all residents of NSW; and
3. State Health administered taxpayer expenditure for NSW public hospitals.

5.3.2.1 MBS and PBS data

MBS and PBS data were purchased for 3 years (2013-14, 2014-15, 2015-16) costing $5,375.56. This cost was generously funded by SWSLHD for dual purposes of supporting an internal SWSLHD project that was subject to a secondary ethics approval and this study. Additional years would be significantly more expensive and was not pursued.

Given that the HORSt is seeking to represent a broad measure of health status of the population, the resources that contribute to the health of the population were similarly sort from inputs that represent a broad contribution to the continuum of care. For the MBS the data purchased was for all categories based on date of processing by age group for each SA3 geographic area for the financial years 2013/14, 2014/15, 2015/16:

- Category 1 - Professional Attendances
- Category 2 - Diagnostic Procedures and Investigations
- Category 3 - Therapeutic Procedures
- Category 4 - Oral and Maxillofacial Services (by Approved Dental Practitioners)
- Category 5 - Diagnostic Imaging Services
- Category 6 - Pathology Services
- Category 7 - Cleft Lip and Cleft Palate
- Category 8 - Miscellaneous Services
- Category 9 - Dentist, Dental Specialist and Dental Prosthetists.
- Category 10 - Dental Benefits Schedule

It is important to note that in June 2018, the AIHW published MBS expenditure for SA3 populations for GP and special attendances on the newly established “My Healthy Communities” website. This information is age-standardised (AIHW 2018a) . However, the data is limited to GP and specialist attendances, Category 1 of the above list (AIHW 2018b; Australian Government 2017). As a proof of concept study, the DEA could have used this data, although it would be somewhat narrower in its resource coverage of the continuum of care than that purchased.

Total scripts and benefits paid for the Pharmaceutical Benefits Scheme (Normal Arrangements PBS and Special Arrangements PBS) for all patient categories based on date of processing by age group for each SA3 geographic area for the financial years 2013/14, 2014/15, 2015/16 were purchased. The included areas of PBS expenditure purchased are:

- General - Ordinary
- Concessional - Ordinary
- General - Safety Net
- Concessional - Free Safety Net

The purchased MBS and PBS data was age-standardised using the same direct method of that of the PPHs data as per equation 14 (page 145), so that every SA3 / DMU had an age-standardised rate of MBS and PBS expenditure per 10,000 people. Congruent with the treatment of the DEA output, the median of the three years age-standardised rate for each DMU for the MBS and PBS was calculated. The median rates for MBS and PBS per 10,000 people were then used as inputs for the DEA.

Table 10 (page 162) and Table 11 (page 164) show a summary of the age-standardised MBS and PBS data to be used as inputs in the study. The tables show that the median costs $'000 per 10,000 people for each SA3 population (DMU) compared to the individual years are a good measure of the populations' normal rate of consumption of MBS and PBS resources with very little variation over the years.

The highest age-standardised median MBS costs per 10,000 people was for the SA3 ***'11502 Dural – Wisemans Ferry' with $11,097,900***. Contrastingly, the lowest age-standardised median MBS costs per 10,000 people were for the SA3 ***'10103 Snow Mountains' with $4,281,700***.

The highest age-standardised median PBS costs per 10,000 people was for the SA3 ***'11703 Sydney Inner City' with $6,243,600***. Contrastingly, the lowest age-standardised median PBS costs per 10,000 people were for the SA3 ***'10103 Snow Mountains' with $1,827,100.***

Table 10 MBS age-standardised costs $'000 per 10,000 people for each NSW SA3 population

SA3 Code & Name	$'000 age standardised per 10,000 people			
	2013-14 MBS	2014-15 MBS	2015-16 MBS	Median MBS
10101 Goulburn – Yass	7348.8	7703.4	7853.2	7703.4
10102 Queanbeyan	6099.7	6635.6	6885.3	6885.3
10103 Snowy Mountains	**3935.6**	**4042.5**	**4281.7**	**4281.7**
10104 South Coast	6834.7	7468.6	7796.1	7796.1
10201 Gosford	9169.0	9526.8	9843.4	9843.4
10202 Wyong	9162.5	9593.5	9851.8	9851.8
10301 Bathurst	7044.2	7374.3	7704.2	7704.2
10302 Lachlan Valley	7874.1	8413.4	8750.9	8750.9
10303 Lithgow - Mudgee	7641.9	7927.8	7963.8	7963.8
10304 Orange	7784.2	8252.3	8432.5	8432.5
10401 Clarence Valley	8535.1	8665.8	8918.1	8918.1
10402 Coffs Harbour	8278.5	9069.9	9155.7	9155.7
10501 Bourke - Cobar - Coonamble	7575.0	8298.1	9102.5	9102.5
10502 Broken Hill and Far West	8185.9	8948.3	9686.2	9686.2
10503 Dubbo	8332.1	8701.0	8787.9	8787.9
10601 Lower Hunter	8152.7	8606.1	8966.6	8966.6
10602 Maitland	7833.6	8576.3	8725.2	8725.2
10603 Port Stephens	8342.2	8827.8	9457.8	9457.8
10604 Upper Hunter	7614.0	8262.8	8602.7	8602.7
10701 Dapto - Port Kembla	9637.6	10200.5	10654.5	10654.5
10703 Kiama - Shellharbour	9434.4	9909.7	10127.8	10127.8
10704 Wollongong	9235.0	9737.5	10035.4	10035.4
10801 Great Lakes	8911.7	9181.5	9297.5	9297.5
10802 Kempsey - Nambucca	8594.4	9289.7	9362.6	9362.6
10804 Port Macquarie	9240.1	9713.3	9829.8	9829.8
10805 Taree - Gloucester	8243.4	8596.1	8593.6	8593.6
10901 Albury	7968.7	8469.5	8471.2	8471.2
10902 Lower Murray	6847.1	7809.4	8081.6	8081.6
10903 Upper Murray exc. Albury	7808.7	8235.8	8301.7	8301.7
11001 Armidale	6583.3	6956.0	7119.6	7119.6
11002 Inverell - Tenterfield	6511.4	6681.9	7104.7	7104.7
11003 Moree - Narrabri	6645.9	7316.2	7651.8	7651.8
11004 Tamworth - Gunnedah	6086.5	6516.6	6880.1	6880.1
11101 Lake Macquarie - East	8788.9	9156.6	9797.6	9797.6
11102 Lake Macquarie - West	8965.6	9426.4	9870.1	9870.1
11103 Newcastle	8494.9	8867.4	9386.8	9386.8
11201 Richmond Valley - Coastal	6011.8	6383.6	6386.7	6386.7
11202 Richmond Valley - Hinterland	7816.1	8006.6	8463.2	8463.2
11203 Tweed Valley	8942.7	9463.6	9963.1	9963.1
11301 Griffith - Murrumbidgee (West)	8288.9	8606.1	8394.0	8394.0
11302 Tumut - Tumbarumba	8240.7	8821.6	8689.4	8689.4
11303 Wagga Wagga	8379.0	8837.8	8684.2	8684.2
11401 Shoalhaven	8472.6	8703.6	8848.4	8848.4
11402 Southern Highlands	8264.8	8692.2	8794.7	8794.7
11501 Baulkham Hills	9722.9	10008.1	10413.0	10413.0
11502 Dural - Wisemans Ferry	10527.8	10906.8	**11097.9**	**11097.9**
11503 Hawkesbury	8806.0	8938.2	9429.1	9429.1

Table 10 continued

SA3 Code & Name	$'000 age standardised per 10,000 people			
	2013-14 MBS	2014-15 MBS	2015-16 MBS	Median MBS
11504 Rouse Hill - McGraths Hill	10060.4	10544.3	10610.2	10544.3
11601 Blacktown	10435.3	10865.6	11086.9	10865.6
11602 Blacktown - North	9788.2	10125.1	10159.0	10125.1
11603 Mount Druitt	9888.1	10158.2	10467.2	10158.2
11701 Botany	8846.3	8932.3	9015.6	8932.3
11702 Marrickville - Sydenham - Petersham	9430.2	9745.7	10026.1	9745.7
11703 Sydney Inner City	9829.8	9937.3	9785.7	9829.8
11801 Eastern Suburbs - North	8692.6	8899.7	9002.6	8899.7
11802 Eastern Suburbs - South	8865.4	9123.9	9033.7	9033.7
11901 Bankstown	9953.0	10294.6	10627.8	10294.6
11902 Canterbury	10311.9	10527.9	10704.1	10527.9
11903 Hurstville	9173.2	9523.8	9422.8	9422.8
11904 Kogarah - Rockdale	8135.1	8322.1	8230.3	8230.3
12001 Canada Bay	9248.1	9587.4	9686.9	9587.4
12002 Leichhardt	9396.1	9735.7	9693.1	9693.1
12003 Strathfield - Burwood - Ashfield	9042.6	9291.5	9226.5	9226.5
12101 Chatswood - Lane Cove	8902.5	9174.9	9155.0	9155.0
12102 Hornsby	8908.9	9163.2	9553.2	9163.2
12103 Ku-ring-gai	9654.7	10006.7	10097.5	10006.7
12104 North Sydney - Mosman	10194.4	10485.4	10463.9	10463.9
12201 Manly	8790.9	9272.8	9261.7	9261.7
12202 Pittwater	8910.9	9301.2	9452.8	9301.2
12203 Warringah	8839.0	9115.3	9210.5	9115.3
12301 Camden	9629.1	10184.0	10405.5	10184.0
12302 Campbelltown (NSW)	**10538.9**	**10937.5**	10856.0	10856.0
12303 Wollondilly	8286.1	8980.9	9184.9	8980.9
12401 Blue Mountains	8200.1	8467.0	8753.8	8467.0
12403 Penrith	9853.9	10210.8	10429.8	10210.8
12404 Richmond - Windsor	9420.7	9576.5	9972.6	9576.5
12405 St Marys	8428.9	8735.8	9379.5	8735.8
12501 Auburn	8778.5	8893.9	8889.8	8889.8
12502 Carlingford	9096.4	9323.2	9619.6	9323.2
12503 Merrylands - Guildford	9775.8	10054.4	10376.6	10054.4
12504 Parramatta	9924.7	10240.6	10517.8	10240.6
12601 Pennant Hills - Epping	9315.3	9594.3	9642.4	9594.3
12602 Ryde - Hunters Hill	8864.9	9191.6	9330.7	9191.6
12701 Bringelly - Green Valley	9428.7	9776.6	9614.3	9614.3
12702 Fairfield	9815.3	10104.0	10323.9	10104.0
12703 Liverpool	9825.6	10310.5	10184.5	10184.5
12801 Cronulla - Miranda - Caringbah	10076.0	10415.2	10566.7	10415.2
12802 Sutherland - Menai - Heathcote	10244.8	10662.6	10985.2	10662.6
Maximum	**10538.92**	**10937.46**	**11097.89**	**11097.89**
Minimum	**3935.62**	**4042.55**	**4281.71**	**4281.71**
Mean	8659.27	9046.83	9244.34	9172.90
Median	8842.62	9159.86	9371.08	9279.58
SD	1177.798	1157.562	1149.498	1111.625

Table 11   PBS age-standardised costs $'000 per 10,000 people for each NSW SA3 population

SA3 Code & Name	$'000 age standardised per 10,000 people 2013-14 PBS	2014-15 PBS	2015-16 PBS	Median PBS
10101 Goulburn – Yass	4012.9	4000.5	4863.0	4012.9
10102 Queanbeyan	3439.0	3342.6	3955.5	3439.0
10103 Snowy Mountains	**1827.1**	**1782.9**	2075.3	**1827.1**
10104 South Coast	4298.1	4309.7	5668.7	4309.7
10201 Gosford	4067.6	3982.3	4676.3	4067.6
10202 Wyong	4659.2	4427.9	5067.6	4659.2
10301 Bathurst	3885.4	3732.1	4189.7	3885.4
10302 Lachlan Valley	4198.6	4125.8	4620.5	4198.6
10303 Lithgow - Mudgee	3855.3	3917.6	4611.0	3917.6
10304 Orange	4079.0	4010.5	4692.8	4079.0
10401 Clarence Valley	4565.4	4592.4	5356.4	4592.4
10402 Coffs Harbour	3835.9	3804.4	4949.3	3835.9
10501 Bourke - Cobar - Coonamble	4331.2	4210.2	4407.1	4331.2
10502 Broken Hill and Far West	4803.6	4881.9	5267.0	4881.9
10503 Dubbo	4303.4	4151.5	4560.8	4303.4
10601 Lower Hunter	4273.5	4149.1	4668.6	4273.5
10602 Maitland	3852.1	3680.1	3892.3	3852.1
10603 Port Stephens	4052.8	4029.1	4484.9	4052.8
10604 Upper Hunter	3672.1	3653.6	4083.6	3672.1
10701 Dapto - Port Kembla	4688.5	4600.1	4950.6	4688.5
10703 Kiama - Shellharbour	4303.7	4331.5	4601.7	4331.5
10704 Wollongong	4143.9	3958.2	4395.5	4143.9
10801 Great Lakes	4471.0	4300.3	5424.4	4471.0
10802 Kempsey - Nambucca	4861.7	4789.6	5814.5	4861.7
10804 Port Macquarie	4448.8	4225.3	4727.8	4448.8
10805 Taree - Gloucester	4263.7	4481.1	5200.2	4481.1
10901 Albury	4086.6	3935.3	4430.2	4086.6
10902 Lower Murray	3844.9	3588.7	4469.4	3844.9
10903 Upper Murray exc. Albury	4175.8	4305.8	4738.0	4305.8
11001 Armidale	3818.1	4084.3	4513.2	4084.3
11002 Inverell - Tenterfield	4016.0	3807.7	4658.8	4016.0
11003 Moree - Narrabri	3726.6	3871.4	4150.3	3871.4
11004 Tamworth - Gunnedah	3516.4	3479.6	4076.2	3516.4
11101 Lake Macquarie - East	4274.6	4209.8	4947.7	4274.6
11102 Lake Macquarie - West	4367.1	4232.6	4988.1	4367.1
11103 Newcastle	4355.6	4232.8	4852.9	4355.6
11201 Richmond Valley - Coastal	1992.1	1870.3	2271.5	1992.1
11202 Richmond Valley - Hinterland	4413.6	4006.5	5033.7	4413.6
11203 Tweed Valley	4103.3	3996.3	5017.6	4103.3
11301 Griffith - Murrumbidgee (West)	4308.2	4244.4	4418.4	4308.2
11302 Tumut - Tumbarumba	4242.4	4142.4	4630.0	4242.4
11303 Wagga Wagga	4307.3	4217.6	4329.6	4307.3
11401 Shoalhaven	4556.8	4343.4	4979.2	4556.8
11402 Southern Highlands	4091.6	4218.8	4508.2	4218.8
11501 Baulkham Hills	3221.9	3222.7	3588.8	3222.7
11502 Dural - Wisemans Ferry	3358.6	3393.8	3551.5	3393.8
11503 Hawkesbury	3393.7	3159.9	4104.7	3393.7

Table 11 continues on next page.

Table 11 continued

SA3 Code & Name	$'000 age standardised per 10,000 people			
	2013-14 PBS	2014-15 PBS	2015-16 PBS	Median PBS
11504 Rouse Hill - McGraths Hill	3374.3	3337.0	3517.3	3374.3
11601 Blacktown	4151.1	3774.5	4463.1	4151.1
11602 Blacktown - North	3269.8	3208.8	3640.5	3269.8
11603 Mount Druitt	4270.9	4046.9	4454.8	4270.9
11701 Botany	3850.7	3646.5	4486.4	3850.7
11702 Marrickville - Sydenham - Petersham	4581.2	4253.9	5660.4	4581.2
11703 Sydney Inner City	**6243.6**	**5910.2**	**7829.2**	**6243.6**
11801 Eastern Suburbs - North	1983.8	1899.6	**2059.8**	1983.8
11802 Eastern Suburbs - South	3668.4	3433.0	4291.2	3668.4
11901 Bankstown	4711.1	4636.1	5283.5	4711.1
11902 Canterbury	4496.4	4376.0	5117.9	4496.4
11903 Hurstville	4071.4	4442.6	4522.9	4442.6
11904 Kogarah - Rockdale	2781.8	2882.2	2504.0	2781.8
12001 Canada Bay	3220.2	3125.8	3848.9	3220.2
12002 Leichhardt	3568.8	3276.2	4283.0	3568.8
12003 Strathfield - Burwood - Ashfield	3471.6	3309.1	4032.6	3471.6
12101 Chatswood - Lane Cove	2965.7	2897.3	3365.1	2965.7
12102 Hornsby	3370.0	3322.8	3577.0	3370.0
12103 Ku-ring-gai	3015.6	3041.7	3366.2	3041.7
12104 North Sydney - Mosman	2858.0	2758.3	3361.1	2858.0
12201 Manly	2872.4	2782.2	3365.2	2872.4
12202 Pittwater	2974.7	2811.1	3169.0	2974.7
12203 Warringah	3300.6	3063.3	3677.2	3300.6
12301 Camden	3920.4	3830.5	4415.7	3920.4
12302 Campbelltown (NSW)	4528.9	4297.8	4948.7	4528.9
12303 Wollondilly	3737.3	3569.9	4342.0	3737.3
12401 Blue Mountains	3137.2	3107.2	3405.7	3137.2
12403 Penrith	3828.1	3855.6	4105.5	3855.6
12404 Richmond - Windsor	4267.9	4011.4	4343.6	4267.9
12405 St Marys	2592.8	2566.0	2810.9	2592.8
12501 Auburn	3821.4	3536.5	4092.0	3821.4
12502 Carlingford	3756.6	3478.4	4103.4	3756.6
12503 Merrylands - Guildford	4489.7	4207.2	4782.5	4489.7
12504 Parramatta	4245.2	3960.0	4267.7	4245.2
12601 Pennant Hills - Epping	3108.9	3126.5	3357.7	3126.5
12602 Ryde - Hunters Hill	3287.5	3276.0	3634.0	3287.5
12701 Bringelly - Green Valley	4234.9	3893.9	4372.7	4234.9
12702 Fairfield	4858.2	4524.1	5383.7	4858.2
12703 Liverpool	3938.6	3657.5	4069.2	3938.6
12801 Cronulla - Miranda - Caringbah	3508.9	3595.1	4013.8	3595.1
12802 Sutherland - Menai - Heathcote	3759.7	3866.6	4229.7	3866.6
Maximum	**6243.56**	**5910.22**	**7829.16**	**6243.56**
Minimum	**1827.09**	**1782.88**	**2059.81**	**1827.09**
Mean	3880.21	3779.88	4341.11	3900.26
Median	4014.42	3905.78	4417.01	4034.36
SD	685.9373	666.073	848.2218	691.6004

Figure 24 and 25 show histograms of the frequency of the age-standardised median MBS and PBS costs per 10,000 people and that of the three years 2013-14, 2014-15, 2015-16. It is apparent from tables 10 and 11 and the graphical presentation of the histograms that there is some small variation in the later years' MBS and PBS costs being somewhat higher than the earlier two years and again as per the statistical literature (Manikandan 2011; Ott 1988, p. 39) the use of the median is a sensible choice to represent the three years in the analysis.

Figure 24 Histogram of the median rate of age-standardised MBS costs for the 88 DMUs used as an input variable in the HORSt DEA and the three years 2013-14, 2014-15, 2015-16

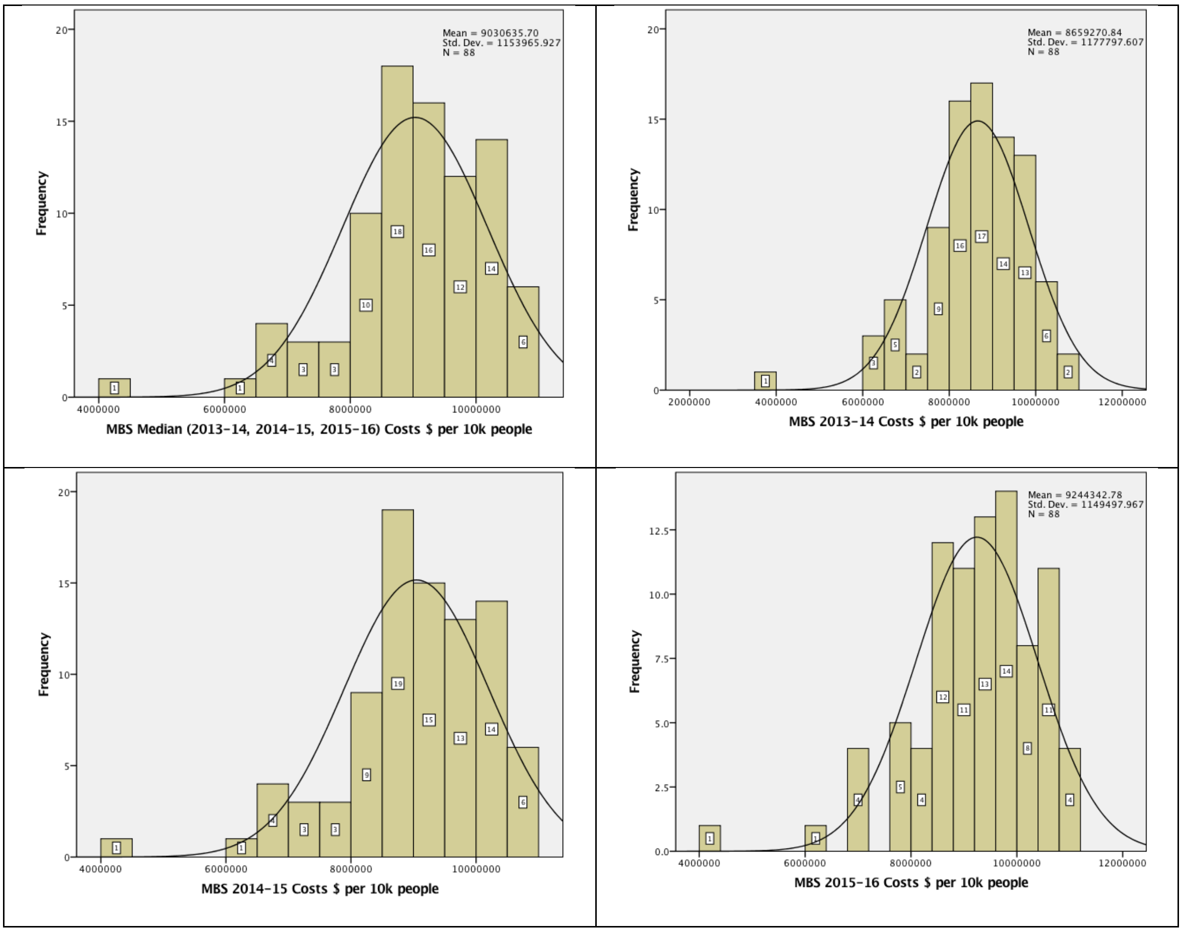


Figure 24 Histograms derived using SPSS software V24 (IBM Corp 2017)

Figure 25 Histogram of the median rate of age-standardised PBS costs for the 88 DMUs used as an input variable in the HORSt DEA and the three years 2013-14, 2014-15, 2015-16

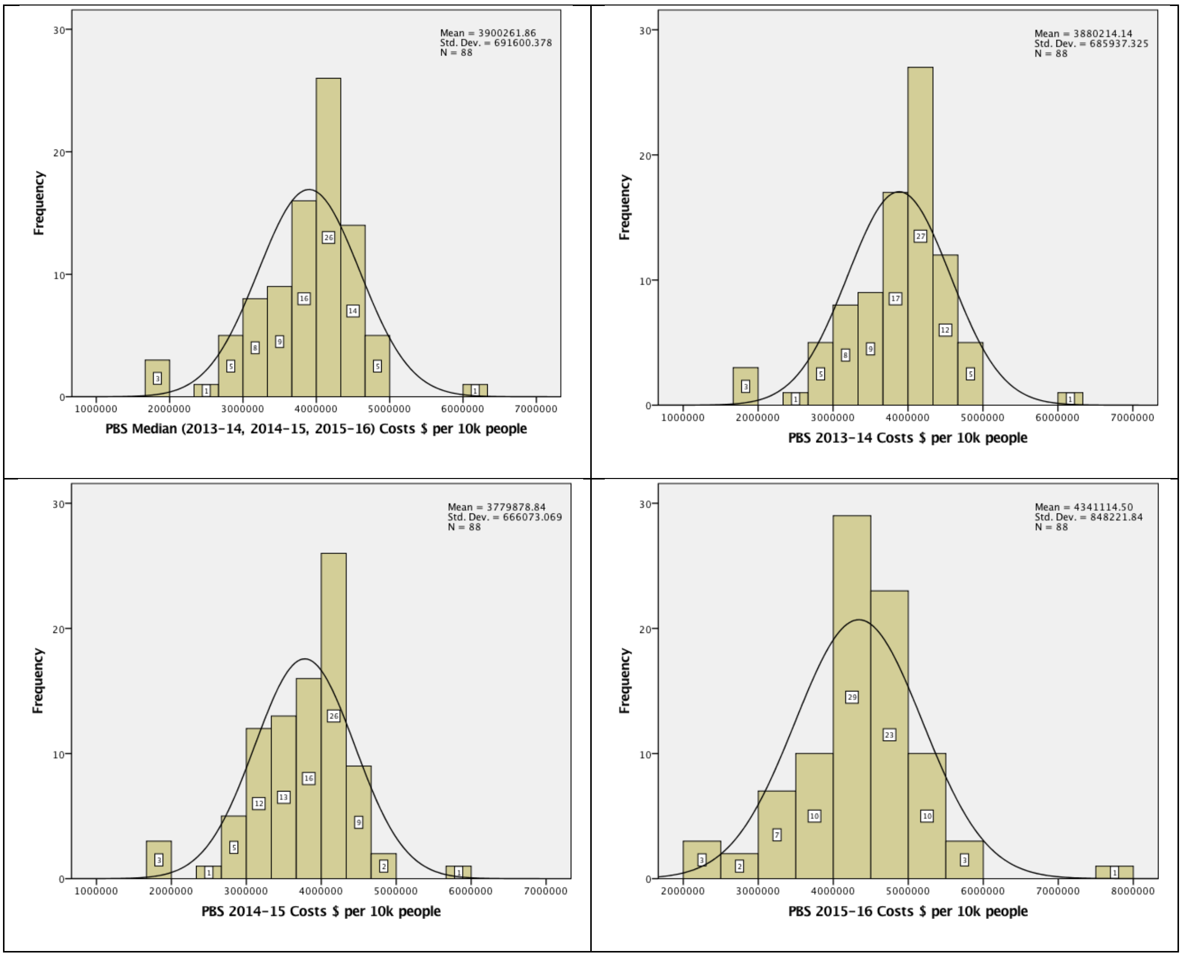


Figure 25 Histograms derived using SPSS software V24 (IBM Corp 2017).

5.3.2.2 State health expenditure

Taxpayer funded state health expenditure in NSW is part funded by NSW and Commonwealth governments (Australian Institute of Health and Welfare 2017a). For the purposes of the DEA as a funding input, it is a source of taxpayer funding administered by the NSW State government.

The NSW State health expenditure was expressed by the calculation of an age-standardised cost ratio (SCRs) of inpatient public hospital separations. An extract of all inpatient hospital separations by SA3 of residence of the patient was conducted for the years 2013/14, 2014/15, 2015/16 from the NSW Health planning tool FlowInfo V17.0 (Clinical Services Planning Analytics 2018). The extract was conducted by 5-year age group and included the NWAU of each separation reflecting the casemix / resource intensity of the patient. It could be contended that this extract of all inpatient hospital separations which also includes PPH separations reflects double counting, given that PPHs are an output for the DEA. However, this is not the case. DEA as discussed is a relative concept that only requires a sensible choice of variables that express the performance of DMUs (Morita & Avkiran 2009, p. 164; Sherman & Zhu 2006b). The PPHs are representing markers, indicators of health status / outcomes, adjusted for resource and patient complexity. These markers as an output are relative to the inputs, whereas the SCRs are reflecting the public hospital sector resource contribution to the continuum of care to the performance of health outcomes / health status at the population level.

Likewise, to the MBS and PBS data, the SCR were age-standardised using the direct method detailed in equation 14 (page 145). Every DMU had an age-standardised rate per 10,000 people calculated for each of the three years. The median of the three years' rates was then used as an input for the DEA.

Table 12 (page 169) shows a summary of the age-standardised median NWAUs data to be used as input representing state health costs in the study. The table shows that the median NWAUs per 10,000 people for each SA3 population (DMU) compared to the individual years are a good measure of the populations' normal rate of consumption of inpatient hospital utilisation with very little variation over the years.

The highest age-standardised median of NWAUs per 10,000 people was for the SA3 ***'10501 Bourke – Cobar –Coonamble' with 4,710.17***. This SA3 had the poorest population health status represented by aged standardised PPH (NWAUs) per 10,000 people, which is logical given that PPHs are a function of inpatient hospital use SCRs. Contrastingly, the lowest age-standardised median of NWAUs per 10,000 people were for the SA3 ***'12601 Pennant Hills - Epping' with 2,068,91.***

Figure 26 (page 171) shows histograms of the frequency of the age-standardised median SCR (NWAUs) per 10,000 people and that of the three years 2013-14, 2014-15, 2015-16. It is apparent from the tables and the graphical presentation of the histograms that there is some small variation in the across the years and again as per the statistical literature (Manikandan 2011; Ott 1988, p. 39) the use of the median is a sensible choice to represent the three years in the analysis.

Table 12 State Health costs expressed as Standardised Costs Ratio (SCR) NWAUs per 10,000 people for each NSW SA3 population

SA3 Code & Name	age standardised per 10,000 people			
	2013-14 SCR (NWAUs)	**2014-15 SCR (NWAUs)**	**2015-16 SCR (NWAUs)**	**Median SCR (NWAUs)**
10101 Goulburn – Yass	2891.26	3039.80	2965.15	2965.15
10102 Queanbeyan	2132.54	2329.13	2347.25	2329.13
10103 Snowy Mountains	**1934.03**	2953.96	2259.46	2259.46
10104 South Coast	3292.83	3309.97	3229.65	3292.83
10201 Gosford	2884.16	2903.96	3049.63	2903.96
10202 Wyong	3148.57	3208.55	3339.84	3208.55
10301 Bathurst	2922.49	2952.64	3222.89	2952.64
10302 Lachlan Valley	3564.20	3559.09	3915.82	3564.20
10303 Lithgow - Mudgee	2878.62	3182.27	3104.86	3104.86
10304 Orange	3348.17	3541.87	3632.20	3541.87
10401 Clarence Valley	3497.06	3570.28	3669.09	3570.28
10402 Coffs Harbour	3505.45	3719.81	3748.30	3719.81
10501 Bourke - Cobar - Coonamble	4506.21	4710.17	**4926.36**	**4710.17**
10502 Broken Hill and Far West	2445.55	3502.09	3790.40	3502.09
10503 Dubbo	3615.59	3783.41	3899.25	3783.41
10601 Lower Hunter	3308.45	3246.73	3190.74	3246.73
10602 Maitland	3514.38	3344.39	3346.04	3346.04
10603 Port Stephens	2936.28	3059.56	3222.52	3059.56
10604 Upper Hunter	3077.77	3308.89	3525.90	3308.89
10701 Dapto - Port Kembla	3377.10	3292.76	3425.92	3377.10
10703 Kiama - Shellharbour	2924.76	3010.07	2947.40	2947.40
10704 Wollongong	2885.58	2854.95	2845.40	2854.95
10801 Great Lakes	3374.67	3318.42	3282.27	3318.42
10802 Kempsey - Nambucca	3835.34	4098.64	4039.81	4039.81
10804 Port Macquarie	3072.79	3099.80	3097.72	3097.72
10805 Taree - Gloucester	3325.94	3304.30	3450.75	3325.94
10901 Albury	2841.99	2928.26	2983.57	2928.26
10902 Lower Murray	2828.66	3390.24	3318.34	3318.34
10903 Upper Murray exc. Albury	2997.41	2956.49	2885.56	2956.49
11001 Armidale	2879.75	3029.69	2966.68	2966.68
11002 Inverell - Tenterfield	3468.99	3257.49	3650.91	3468.99
11003 Moree - Narrabri	3316.02	3469.19	3602.61	3469.19
11004 Tamworth - Gunnedah	3750.38	3773.26	3723.93	3750.38
11101 Lake Macquarie - East	2918.90	2838.45	2944.62	2918.90
11102 Lake Macquarie - West	3062.96	2970.91	3198.02	3062.96
11103 Newcastle	2957.81	2984.85	3059.88	2984.85
11201 Richmond Valley - Coastal	2280.49	2311.81	2319.63	2311.81
11202 Richmond Valley - Hinterland	3397.10	3257.82	3321.11	3321.11
11203 Tweed Valley	2323.55	2467.30	2388.35	2388.35
11301 Griffith - Murrumbidgee (West	3545.82	3672.72	3585.09	3585.09
11302 Tumut - Tumbarumba	3395.18	3433.67	3818.23	3433.67
11303 Wagga Wagga	3407.29	3461.55	3545.70	3461.55
11401 Shoalhaven	3291.60	3425.96	3442.09	3425.96
11402 Southern Highlands	3041.83	3059.06	3030.82	3041.83
11501 Baulkham Hills	2302.52	2351.46	2298.76	2302.52
11502 Dural - Wisemans Ferry	2678.05	2687.06	2691.53	2687.06
11503 Hawkesbury	2770.69	2796.87	2946.76	2796.87

Table 12 continued

SA3 Code & Name	age standardised per 10,000 people			
	2013-14 SCR (NWAUs)	2014-15 SCR (NWAUs)	2015-16 SCR (NWAUs)	Median SCR (NWAUs)
11504 Rouse Hill - McGraths Hill	2429.77	2708.98	2624.82	2624.82
11601 Blacktown	3680.13	3700.87	3886.93	3700.87
11602 Blacktown - North	2672.12	2675.56	2784.97	2675.56
11603 Mount Druitt	4505.91	**4725.46**	4560.64	4560.64
11701 Botany	3091.76	3218.97	3475.23	3218.97
11702 Marrickville - Sydenham - Petersham	3252.22	3148.49	3202.41	3202.41
11703 Sydney Inner City	3096.82	3021.09	2961.36	3021.09
11801 Eastern Suburbs - North	2567.24	2325.36	2420.70	2420.70
11802 Eastern Suburbs - South	3181.24	3185.67	3162.16	3181.24
11901 Bankstown	2935.48	2970.96	2959.19	2959.19
11902 Canterbury	3100.23	3126.35	3256.37	3126.35
11903 Hurstville	2424.31	2434.85	2420.14	2424.31
11904 Kogarah - Rockdale	3153.38	3311.58	3127.59	3153.38
12001 Canada Bay	2405.76	2375.70	2400.87	2400.87
12002 Leichhardt	2636.30	2709.68	2710.78	2709.68
12003 Strathfield - Burwood - Ashfield	2402.09	2523.00	2534.04	2523.00
12101 Chatswood - Lane Cove	2339.62	2449.20	2331.55	2339.62
12102 Hornsby	2445.19	2513.13	2552.90	2513.13
12103 Ku-ring-gai	2242.85	2322.87	2235.24	2242.85
12104 North Sydney - Mosman	2990.68	2860.77	2934.54	2934.54
12201 Manly	2674.25	2595.77	2764.93	2674.25
12202 Pittwater	2651.90	2593.19	2797.69	2651.90
12203 Warringah	2595.32	2605.32	2666.35	2605.32
12301 Camden	2742.87	2873.99	3060.90	2873.99
12302 Campbelltown (NSW)	3751.19	3798.85	3817.98	3798.85
12303 Wollondilly	2857.50	2935.96	2966.01	2935.96
12401 Blue Mountains	2756.11	2903.32	3015.68	2903.32
12403 Penrith	3422.74	3342.68	3584.90	3422.74
12404 Richmond - Windsor	3186.49	3335.90	3531.55	3335.90
12405 St Marys	**4585.00**	4380.97	4420.26	4420.26
12501 Auburn	3053.76	3104.24	3248.59	3104.24
12502 Carlingford	2524.61	2617.51	2572.65	2572.65
12503 Merrylands - Guildford	3007.22	3023.43	3091.05	3023.43
12504 Parramatta	2930.10	3001.50	2903.88	2930.10
12601 Pennant Hills - Epping	2090.73	**2068.91**	**2031.83**	**2068.91**
12602 Ryde - Hunters Hill	2546.03	2665.42	2562.42	2562.42
12701 Bringelly - Green Valley	3192.15	3109.49	3248.71	3192.15
12702 Fairfield	2710.90	2783.47	2713.31	2713.31
12703 Liverpool	3519.86	3387.08	3323.53	3387.08
12801 Cronulla - Miranda - Caringbah	2647.47	2734.24	2744.65	2734.24
12802 Sutherland - Menai - Heathcote	2677.94	2657.25	2853.89	2677.94
Maximum	**4585.00**	**4725.46**	**4926.36**	**4710.17**
Minimum	**1934.03**	**2068.91**	**2031.83**	**2068.91**
Mean	3015.16	3085.87	3132.50	3073.11
Median	2974.25	3034.75	3094.39	3032.63
SD	509.1432	499.5848	538.5081	506.0761

Figure 26 Histogram of the median rate of age-standardised SCR (NWAUs) for the 88 DMUs used as an input variable in the HORSt DEA and the three years 2013-14, 2014-15, 2015-16

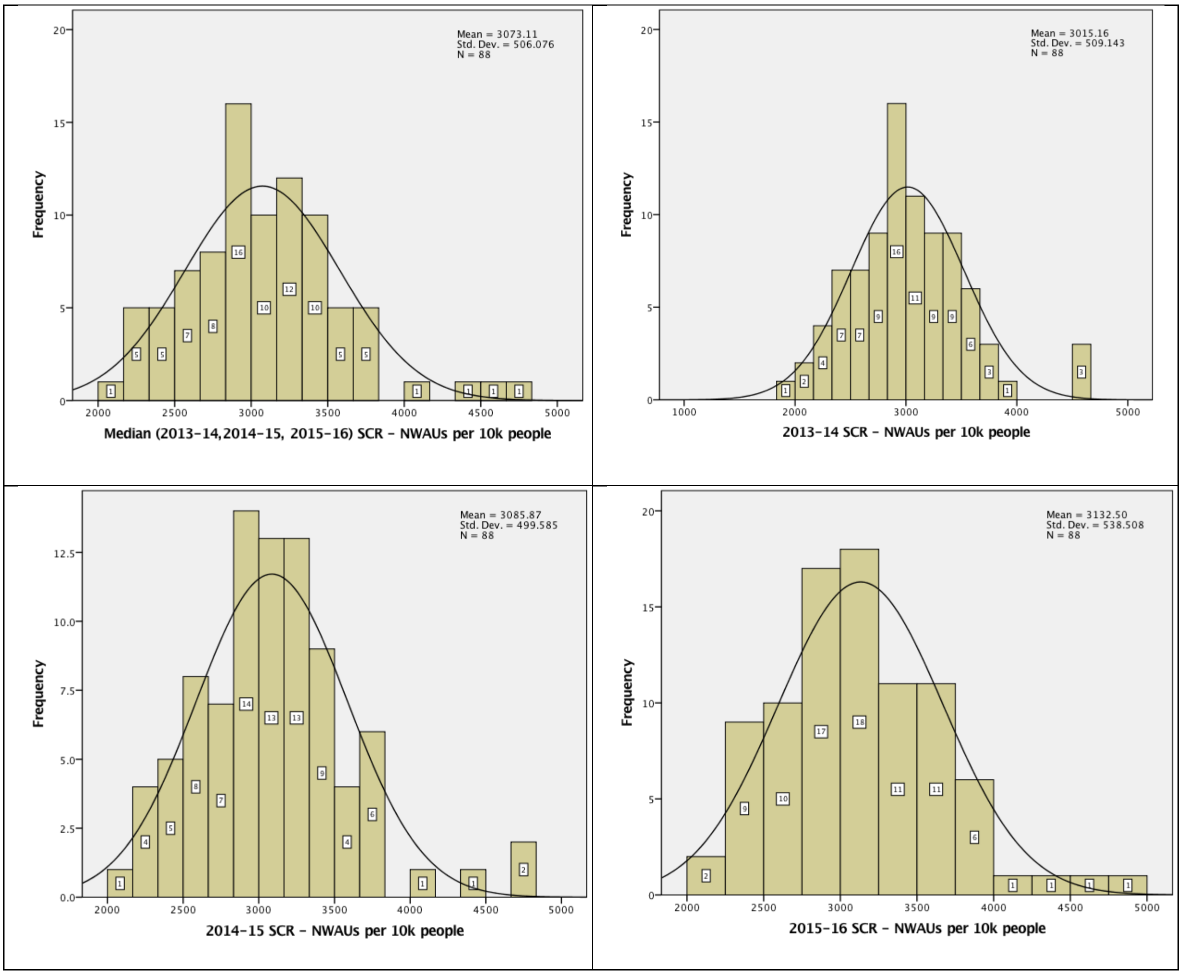


Figure 26 Histograms derived using SPSS software V24 (IBM Corp 2017).

5.4 REGRESSION -DEPENDENT VARIABLE

As discussed in the previous chapter (page 122) regarding two-stage DEA, the dependent variable for the regression will be the allocative efficiency scores of population health status measured by the DEA for the 88 DMUs / SA3 populations.

5.5 REGRESSION - INDEPENDENT VARIABLES

The independent variables considered for the HORSt regression are informed by the literature of social determinants that are known in a formative construct to give rise to health inequalities and therefore logically can give rise or form to the allocative efficiency of health status measured by the DEA allocative efficiency scores. As correlation methods such as regression models do not indicate the direction of interaction between variables, it is important for the research to accurately consider the nature of the construct's direction in the selection of explanatory variables (Leedy & Ormrod 2010, p. 185). If the direction of interaction between the variables is misspecified in a correlation model, variables thought to be associated may not be and correlation coefficients in predictive models may be in error (Jarvis 2014; Roy et al. 2012). Formative constructs imply that correlating variables would give form to the construct, whereas reflective constructs imply that correlating variables are reflected from the construct (Coltman et al. 2008; Diamantopoulos & Siguaw 2006; Jarvis 2014).

As outlined by Field (2013, p. 321) independent variable selection should be judicious, parsimonious and be based on sound theoretical knowledge and well conducted research. In particular, to contextualise the model to Australian data sources, the data sources of predictor variables of former NSW RDF and development of the latest iteration the NSW Expected Health Utilisation Need Indices (EHUIs) were considered along with the underlying literature. As outlined in the literature review the former RDF and EHUIs utilised formative constructs; both sought variables that give rise to inpatient utilisation as a measure of health need.

Variables that represent seven categories of social determinants that are demonstrated in the literature to give rise to health inequalities that affect health outcomes for individuals and within populations are to be tested in the HORSt regression analysis. These are:

1. lower socioeconomic status;
2. living in rural and remote communities;
3. indigenous status;
4. living with a disability
5. living with mental illness;
6. migrants with low levels of English; and
7. affordability / financial barrier of access to private primary care services.

Ultimately the regression model will not feature variables for all of these categorises as there is overlap amongst these categories. Furthermore, as this section will show there is overlap amongst some of the variables representing them. Seeking a parsimonious robust regression that fits the data, the regression analysis will consider the combined linear predictive effects of independent variables to explain the variation in the DEA allocative efficiency scores. Doing so, the regression analysis will eliminate variables that are not significant and ultimately reduce the number of independent variables in the regression model that best fits the data.

The first six categories listed above were introduced in Chapter One and are well supported contextually in the Australian literature as social determinants of health (Allan et al. 2007; Australian Institute of Health and Welfare 2016a; NSW Department of Health 2004; Palmer & Short 2014; Turrell et al. 2006).

A seventh category will consider out-of-pocket expenses at the population level that represent the affordability and / or financial barriers to access private predominately primary care services. Inclusion of this is fourfold. First, as discussed in the literature review, it is well established that delays in treatment due to financial constraints may give rise to worst health inequalities and poorer health outcomes (Kraft et al. 2009; Mollborn et al. 2005; Prentice & Pizer 2007). Second, at the time of this research, Australians are facing more than ever growing out-of-pocket costs for private health care, around 20% of the total Australian Health Care expenditure, which is higher than the OECD average of 19% (OECD 2015), which has resulted in an Australian Government Senate inquiry (Community Affairs References Committee 2014). Third, in response to the second, the Australian Government has made available for the first time variables reflecting out-of-pocket consumer costs at the population level including SA3s for non-hospital Medicare subsided treatment (Australian Institute of Health and Welfare 2018d). Fourth, as proven in the literature it is entirely likely that populations that cannot afford private sector access will eventually substitute the lack of private sector access with public sector services such as the ED in public hospitals and at higher costs to the tax payer (Eckermann 2014a, 2014b; Eckermann et al. 2016). It would seem therefore logical that vertical equity financial loadings informed by the HORSt regression analysis should consider the significance of out-of-pocket costs on the benchmarked allocative efficiency of health outcomes.

The former NSW RDF and EHUI considered and used variables comprising the first six social determinant categories listed above but also included premature standardised mortality ratios (SMRs) less than 70 years of age (Health Policy Analysis 2014a, 2014b; Inter-Government & Funding Strategies 2005b; Marshall & Slater 2015). However, using SMRs is problematic for the formative construct validity of the former RDF, the EHUIs and the HORSt. Premature deaths data as per the SMR does not give rise to health status or health utilisation, rather SMRs logically reflect these. Therefore, the use of SMR data in a reflective construct would be correctly specified but incorrectly specified in a formative construct. For the HORSt it is difficult to see how deaths data could give rise to the allocative efficiency or inefficiency of health status measured by PPHs. As such SMR data will not be considered in the HORSt regression.

Independent variable selection for the HORSt regression analysis for each of the seven categories identified will utilise data from established secondary data sources for the SA3 populations. It is likely that there will be correlations between the independent variables as there are obvious intersections between the social determinant categories, such as people of lower socioeconomic status living with a disability etc. The regression analysis will ultimately test each of the variables consistent with the axioms outlined in the previous chapter (page 128) and develop a parsimonious model of best fit with far fewer predictors than the variables that are now critiqued.

5.5.1 Socioeconomic variables from the 2016 ABS Census

Utilising census data, the ABS develops Socioeconomic Indices for Areas (SEIFA) that ranks geographical areas by the relative socioeconomic advantage and disadvantage of their collective populations. The SEIFA indices are for collective populations, not individuals and are established from census data (Australian Bureau of Statistics 2018d, pp. 4,6). There are four key socioeconomic variables that are produced by the ABS being:

- Index of Relative Socio-economic Disadvantage (IRSD);
- Index of Relative Socio-economic Advantage and Disadvantage (IRSAD);
- Index of Education and Occupation (IEO); and
- Index of Economic Resources (IER).

The current version is for the 2016 census. The indices overtime a broadly comparable with previous versions, of other censuses of 2001, 2006 and 2011 (Australian Bureau of Statistics 2018d, p. 4).

The indices produced are ordinal rankings and at the lowest population level applied (SA1), 1,000 represents the mean of the rankings. Higher scores represent higher socioeconomic ranking and vice versa. However, the produced index numbers are not proportionally comparable. For example an area having an index of 1,100 is not twice that as socioeconomically advantaged as an area having an index of 550 (Australian Bureau of Statistics 2018d, pp. 18, 30).

All are indices constructed from multiple data collected at the census and utilise principal component analysis, a method to reduce a large number of correlated data into uncorrelated principal components (meaningful dimensions) that are useful for supporting each indices assessments of the population socioeconomic advantage and disadvantage (Australian Bureau of Statistics 2018d, p. 15). The dimensions identified and included for use in the indices are summarised in the Table 13. As each individual index contains some of the same principal components and some of the same underlying variables these indices correlate with each other.

With the HORSt regression bi-variate correlation analysis will demonstrate the extent of the correlations. Regression options modelled will not contain multiple SEIFA indices due to the multicollinearity.

Table 13 Principal components / dimensions used with 2016 ABS SEIFA indices

Dimension	2016 SEIFA Indices			
	IRSD	IRSAD	IER	IEO
Income	☑	☑	☑	
Education	☑	☑		☑
Employment	☑	☑	☑	☑
Occupation	☑	☑		☑
Housing	☑	☑	☑	
Other	☑	☑	☑	

(Australian Bureau of Statistics 2018d, p. 39).

The ABS definitions of the four SEIFA indices are presented herein. Accompanying tables showing the included census measures aligned to the six dimensions of each index are provided. Variable weightings are applied by the ABS to construct a single index number of each SA1 and SA2 population. The individual census variable weightings that make up the index for each population area not relevant to the HORSt and are not presented. By contrast, the index numbers for each of the four SEIFA indices for the population levels are relevant and, importantly, the ABS only compile the four indices at SA1 and SA2 population levels. However, within the ABS Technical paper there is a formula designed to permit the calculation of these indices at SA3 and higher levels, which is required to support the HORSt regression analysis. This ABS formula depicted in equation 20 was utilised so as to compute SEIFA indices for each SA3 population.

Equation 20 – ABS formula for creating higher geographical level SEIFA indices from SA1 to SA3

$$INDEX_{SA3(i)} = \frac{\sum_{i=1}^{n}(INDEX_{SA1(i)} \times POP_{SA1(i)})}{POP_{SA3\,(i)}}$$

where:

$INDEX_{SA1(i)}$ = index score for each SA1

$POP_{SA1(i)}$ = Population for each SA1

$POP_{SA3(i)}$ = Population for the SA3

n = Total number of SA1s with index scores in SA3(i)

(Australian Bureau of Statistics 2018d, p. 18).

It is important to note that at higher calculated levels, such as the SA3, that the indices do not have the same average around 1,000 as that of the SA1 levels as the higher levels are not standardised in this way (Australian Bureau of Statistics 2018d, p. 18).

It could be argued that the calculated indices at the higher population levels do not have the same level of visibility of socioeconomic advantage or disadvantage in small areas as per the SA1 levels. However, the SA3 indices derived from the ABS formula designed to do so, nonetheless represent the socioeconomic rankings of the SA3 populations that take into account the SA1 socioeconomic index rankings weighted for the SA1 populations that make up the SA3.

Given the literature's findings of socioeconomic status being associated with health outcomes and in particular PPHs, it is expected that for each of the SEIFA indices, high socioeconomic status will be associated with high rates of population health status and higher rates of allocative efficiency associated with the production of desirable health outcomes and vice versa.

The individual SEIFA indices are now outlined in detailed.

IRSD

"The IRSD summarises variables that indicate relative disadvantage. This index ranks areas on a continuum from most disadvantaged to least disadvantaged. A low score on this index indicates a high proportion of relatively disadvantaged people in an area " (Australian Bureau of Statistics 2018d, p. 6).

Table 14 shows a summary of the census variables included in the IRSD index.

Table 14 IRSD with component census variables

Dimension	Variable Description
Income	% People with stated annual household equivalised income between $1 and $25,999 (approx. 1st and 2nd deciles).
Education	% People aged 15 years and over whose highest level of education is Year 11 or lower. Includes Certificate I and II. % People aged 15 years and over who have no educational attainment.
Employment	% People (in the labour force) unemployed.
Occupation	% Employed people classified as labourers. % Employed people classified as Machinery Operators and Drivers. % Employed people classified as Low Skill Community and Personal Service Workers.
Housing	% Occupied private dwellings paying rent less than $215 per week (excluding $0 per week). % Occupied private dwellings requiring one or more extra bedrooms (based on Canadian National Occupancy Standard).
Other	% Families with children under 15 years of age who live with jobless parents. % One parent families with dependent offspring only. % Occupied private dwellings with no cars. % People aged under 70 who have a long–term health condition or disability and need assistance with core activities. % People who do not speak English well. % People aged 15 and over who are separated or divorced. % Occupied private dwellings with no internet connection.

(Australian Bureau of Statistics 2018d, pp. 19-20).

IRSAD

"The IRSAD summarises variables that indicate either relative advantage or disadvantage. This index ranks areas on a continuum from most disadvantaged to most advantaged. An area with a high score on this index has a relatively high incidence of advantage and a relatively low incidence of disadvantage" (Australian Bureau of Statistics 2018d, pp. 6-7).

Table 15 shows a summary of the census variables included in the IRSAD index.

Table 15   IRSAD with component census variables

Dimension	Variable Description
Income	% People with stated annual household equivalised income between $1 and $25,999 (approx. 1st and 2nd deciles). % People with stated annual household equivalised income greater than $78,000 (approx. 9th and 10th deciles).
Education	% People aged 15 years and over whose highest level of education is Year 11 or lower. Includes Certificate I and II. % People aged 15 years and over who have no educational attainment. % People aged 15 years and over whose highest level of educational attainment is a certificate III or IV qualification. % People aged 15 years and over at university or other tertiary institution. % People aged 15 years and over whose highest level of education attainment is a diploma qualification.
Employment	% People (in the labour force) unemployed.
Occupation	% Employed people classified as labourers. % Employed people classified as Machinery Operators and Drivers. % Employed people classified as Low Skill Community and Personal Service Workers. % Employed people classified as Low Skill Sales. % employed people classified as Managers. % Employed people classified as Professionals.
Housing	% Occupied private dwellings paying rent less than $215 per week (excluding $0 per week). % Occupied private dwellings requiring one or more extra bedrooms (based on Canadian National Occupancy Standard). % Occupied private dwellings with four or more bedrooms. % Occupied private dwellings paying rent greater than $470 per week. % Occupied private dwellings paying mortgage greater than $2,800 per month.
Other	% Families with children under 15 years of age who live with jobless parents. % One parent families with dependent offspring only. % Occupied private dwellings with no cars. % People aged under 70 who have a long–term health condition or disability and need assistance with core activities. % People aged 15 and over who are separated or divorced. % Occupied private dwellings with no internet connection.

(Australian Bureau of Statistics 2018d, pp. 20-1).

IER

"The IER summarises variables relating to the financial aspects of relative socio-economic advantage and disadvantage. These include indicators of high and low income, as well as variables that

correlate with high or low wealth. Areas with higher scores have relatively greater access to economic resources than areas with lower scores" (Australian Bureau of Statistics 2018d, p. 7).

Table 16 shows a summary of the census variables included in the IER index.

Table 16 IER with component census variables

Dimension	Variable Description
Income	% People with stated annual household equivalised income between $1 and $25,999 (approx. 1st and 2nd deciles). % People with stated annual household equivalised income greater than $78,000 (approx 9th and 10th deciles).
Employment	% People aged 15 years and over who are unemployed
Housing	% Occupied private dwellings paying rent less than $215 per week (excluding $0 per week). % Occupied private dwellings requiring one or more extra bedrooms (based on Canadian National Occupancy Standard). % Occupied private dwellings owning dwelling without a mortgage. % Occupied private dwellings with four or more bedrooms. % Occupied private dwellings paying mortgage greater than $2,800 per month.
Other	% Dwellings with at least one person who is an owner of an unincorporated enterprise. % One parent families with dependent offspring only. % Occupied private dwellings with no cars. % Occupied private dwellings who are group occupied private dwellings. % Occupied private dwellings who are lone person occupied private dwellings.

Source: (Australian Bureau of Statistics 2018d, pp. 21-2).

IEO

"The IEO summarises variables relating to the educational and occupational aspects of relative socio-economic advantage and disadvantage. This index focuses on the skills of the people in an area, both formal qualifications and the skills required to perform different occupations. A low score indicates that an area has a high proportion of people without qualifications, without jobs and/or with low skilled jobs. A high score indicates many people with high qualifications and/or highly skilled jobs" (Australian Bureau of Statistics 2018d, p. 7).

Table 17 shows a summary of the census variables included in the IRSD index.

Table 17 IEO with component census variables

Dimension	Variable Description
Education	% People aged 15 years and over whose highest level of education is Year 11 or lower. Includes Certificate I and II. % People aged 15 years and over whose highest level of educational attainment is a certificate III or IV qualification. % People aged 15 years and over at university or other tertiary institution. % People aged 15 years and over whose highest level of education attainment is a diploma qualification.
Employment	% People (in the labour force) unemployed.
Occupation	% Employed people who work in a Skill Level 1 occupation. % Employed people who work in a Skill Level 2 occupation. % Employed people who work in a Skill Level 4 occupation. % Employed people who work in a Skill Level 5 occupation.

(Australian Bureau of Statistics 2018d, p. 22).

5.5.2 Accessibility and Remoteness Index of Australia (2011 ARIA)

The literature indicates that people living in rural and remote areas face high rates of health inequalities related to the access of health services and have poorer health outcomes than people in more urbanised areas (Australian Institute of Health and Welfare 2007, 2016a, 2016b). In Australia access to services and remoteness are measured by the Accessibility and Remoteness Index of Australia (ARIA) which classifies geographical areas of Australia into five classes of remoteness being:

1. Major cities;
2. Inner regional;
3. Outer regional;
4. Remote; and
5. Very Remote

(Australian Bureau of Statistics 2018c).

ARIA is produced by the Hugo Centre for Migration and Population Research at the University of Adelaide who can supply ARIA at cost scores for all ABS geographies (including SA3s) and non-ABS geographies such as LGAs. The scores ranging from 0 to 15 and calculated to two decimal places whereby lower scores represent great access to services and vice versa. The scores themselves are calculated based on road distances of populations' locations to nearest service centre (major settlement) within each of the five remoteness categories and divided by the national average in each category. The version of ARIA applicable to the 2011 version SA3 geographies used in the HORSt is called ARIA+ (Hugo Centre for Migration and Population Research 2018a).

The inclusion of this variable in the regression analysis is logically sensible and supported by the literature including the former NSW RDF and EHUIs that used it (Health Policy Analysis 2014b; Inter-Government & Funding Strategies 2005b). However, there is no guarantee that the variable would be a significant linear predictor of the DEA Allocative Efficiency scores in a regression model containing other variables. Given this risk and due to financial limitations of this study, the costs of purchasing the ARIA data for the NSW SA3s were deemed prohibitive.

A free version demonstration version of the ARIA+ scores at SA3 level is available for download. This data lacks the precision of the purchased scores to two decimal places and provides the ARIA+ to the nearest whole number (Hugo Centre for Migration and Population Research 2018b). Given the literature's strong position on ARIA being a social determinant of health the downloaded data which requires a separate download for each SA3 was nonetheless pursued and the ARIA+ scores to the nearest whole number were included in the regression analysis for assessment.

5.5.3 Aboriginal and Torres Strait Islander peoples (2016 Census)

The health inequalities faced by indigenous Australians in particular are a blunt contrast to Australian norms. For example, in 2011-12 the average life expectancy for indigenous Australian males and females was 10.6 and 9.5 years less respectively compared to non-indigenous Australians (Department of the Prime Minister and Cabinet 2018, p. 104). In addition to reduced life expectancy, indigenous Australians have higher rates of associated morbidity than non-indigenous Australians and higher rates of social disadvantage. For example:
"Blinding cataract is 12 times more common in indigenous Australians adults than non-Indigenous adults but the rates of cataract surgery are seven times lower. Cataracts cause 32% of blindness in indigenous Australians adults and 27% of low vision. 94% of vision loss for indigenous Australians Islander people is preventable or treatable, but only 65% of those with vision loss caused by cataracts have received surgery"(Holland 2014, p. 9).

A key initiative of Australian Government's, *Closing the Gap,* was established in 2008 to tackle these serious health inequalities of indigenous Australians. This initiative remains a priority of all levels of Government in Australia (Australian Institute of Health and Welfare 2015b; Holland 2014).

Given the poor health outcomes of the indigenous Australian community, the proportion of people who identify as Aboriginal or Torres Strait Islander people amongst SA3 populations will be included in the regression analysis. It would be expected that populations that have higher rates of indigenous Australians would have poorer health outcomes and lower rates of allocative efficiency associated with those outcomes. The latest 2016 Census data of "Estimates of Aboriginal and Torres Strait Islander Australians, June 2016" will be utilised for this purpose (Australian Bureau of Statistics 2018b).

5.5.4 Disability – Assisted Needs Population (2016 Census)

People living with disabilities are known to have poorer health outcomes and have lower socioeconomic means (Australian Institute of Health and Welfare 2010, 2016b). The key Census statistic for assessing people living with disabilities is the 'Core Activity Need for Assistance (ASSNP)' variable (Australian Bureau of Statistics 2017e). The 2016 Census data for SA3s is available via the ABS online data base 'Table builder' (Australian Bureau of Statistics 2017a). This data was downloaded as a portion of the 2016 population for inclusion in the regression.

Given the literature, it is expected that populations that have higher proportions of people requiring assistance, will have poorer health outcomes and lower rates of allocative efficiency associated with those outcomes. However, with due consideration to the SEIFA variables discussed, elements of the population with assisted needs under 70 years are included in the IRSD and IRSAD indices. Given this and the literature noted above, it is possible that in a regression analysis the Assisted Needs variable might give rise to multicollinearity problems with the SEIFA indices and or be a non-significant linear predictor of the DEA Allocative efficiency score in a regression containing a SEIFA index. Nonetheless, the literature indicates that variable is well worth assessment in the regression analysis.

5.5.5 Health and wellbeing and risk of Mental illness – Lone Person Households (2016 Census)

According to the Australian Institute of Health and Welfare (2015a), there are a number of risk factors for health and wellbeing and mental health associated with people living on their own. Specifically, people living alone:

- are more than twice as likely to have three or more social determinants that lead to poorer health than couples or families;
- have an increased risk of developing mental health problems; and
- 15% of people living with mental illness live in single person households.

Furthermore, according to de Vaus and Qu (2015), lone person households were more likely to engage in excessive alcohol and tobacco consumption than households containing couples and families. Given that living alone is a risk factor to health outcomes, this variable will be included in the regression analysis, where it could be expected that higher numbers of lone person households yield poorer health outcomes and lower rates of allocative efficiency associated with those outcomes.

The SEIFA index IER includes lone person dwellings and there maybe issues of significance for this variable in a regression model containing IER or another SEIFA index that correlates with or represents social determinants known in the literature to be associated with people living alone.

The number of lone person households is collected on the Census via questions regarding Family Composition (Australian Bureau of Statistics 2017f). The data was extracted via the ABS Stat database for SA3 populations (Australian Bureau of Statistics 2017c).

5.5.6 Migrant populations - No or Poor English (2016 Census)

"Immigrants from English-speaking countries were found to have advantages related to physical health, mental health and self-assessed health. English proficiency had an effect on the difference in health between populations, as a language barrier could hinder an individual's access to health services. It can also have an impact on employment, which has broader socioeconomic implications" (Australian Institute of Health and Welfare 2018a).

Given the literature relating to hindered access of services due to poor English proficiency, it could be expected that populations that have higher rates of poor English proficiency have poorer health outcomes and lower rates of allocative efficiency associated with those outcomes.

The SEIFA index IRSD includes people who cannot speak English very well and there maybe significance problems in a regression for this variable, where the regression also contains IRSD or another SEIFA index that covers broader socioeconomic issues that the literature documents as having an association with migrants with poor English. Nonetheless the variable will be assessed in the regression analysis.

The Census statistic for assessing peoples' English proficiency is the 'Proficiency in Spoken English (ENGP)' variable (Australian Bureau of Statistics 2017h). The 2016 Census data for SA3s is available via the ABS online data base 'Table builder' (Australian Bureau of Statistics 2017b). Two categories of English proficiency, 'no-English' or 'poor English', were downloaded and combined as a portion of the 2016 population for inclusion in the regression analysis.

5.5.7 Out-of-pocket health expenses (AIHW)

The systematic public reporting of out-of-pocket health expenses by ABS geographical areas is relatively new in Australia. In 2018, the Australian Institute of Health and Welfare released information at the SA3 level via report (Australian Institute of Health and Welfare 2018c) and via downloaded data (Australian Institute of Health and Welfare 2018a). The reports and data show out-of-pocket costs for non-hospital Medicare subsidised services for:

- GP services;
- Specialists;
- Obstetrics;
- Diagnostics and Imaging; and
- A total of the above.

At the time of this study the AIHW data is only available for the 2016/17 financial year. The data is reported for populations as the percentage of patients with out-of-pocket costs, the median out-of-pocket costs of patients and the out-of-pocket costs of patients of the 90th percentile for each SA3 are available (Australian Institute of Health and Welfare 2018a).

For assessment in the regression analysis, data will include the portion of the populations with out-of-pocket costs for: GP services; Specialists; Diagnostics and Imaging; and the total of all these categories which also includes obstetrics. Obstetrics out-of-pocket costs will not be assessed on its own as unlike the other categories it covers a very narrow specific area of health, whereas the HORSt is seeking a broad view of the overall health status of the community. However, due to the nature of the proportional population data available, Obstetrics costs are already included in the total proportions and will not be able to be removed so it is not possible to consider a total proportion for GPs, Specialists and Diagnostic and Imaging together.

As per the literature that finds out-of-pocket costs act as a barrier to private non-admitted primary care services, it is expected that populations' that have higher portions of patients with out-of-pocket costs will have better health outcomes and in turn better allocative efficiency associated with those outcomes as the costs incurred represent an ability to pay for access to private services. Contrastingly, populations with lower portions of out-of-pocket costs will have a lower ability to pay to access private services, which may result through delay in worsening health outcomes, compromising allocative efficiency.

Importantly, the underlying logic of the use of out-of-pocket costs in the regression is not saying that individuals within populations with out-of-pocket costs do not face financial burdens to pay. However, at the population level it is reasonable to assume that populations with higher portions of out-of-pocket costs have a greater capacity and or willingness to pay to access private services than those populations with lower portions. Furthermore, this logic is not saying that higher portions of out-of-pocket costs cause better health outcomes and improve allocative efficiency associated with those outcomes. The logic underpinned by the literature is positioning out-of-pocket costs as representative of the financial ability of populations to access private primary care services. If the financial access to private primary care services that populations require is lower, it is reasonable to expect that the health outcomes of those populations could be compromised along with the accompanying allocative efficiency of those outcomes.

5.5.8 Summary of Independent Variables for each SA3 to be assessed for the HORSt regression

Table 18 shows that for 2016 that:

- SA3 12702 Fairfield has the lowest IRSD and IEO of 860.9 and 883.9 respectively;
- SA3 11730 Sydney Inner City had the lowest IER 884.6 and highest amount of lone person households 32,415;
- SA3 10802 Kempsey Nambucca had the lowest IRSAD 884.6;
- SA3 12103 Ku-ring-gai had the highest IRSD and IRSAD 1121.0 and 1166.6 respectively,
- SA3 12104 North Sydney - Mosman had the highest IEO 1192.9;
- SA3 11504 Rouse Hill - McGraths Hill had the highest IER 1154.8 and lowest number of lone person households 976;
- the highest ATSI proportion was at SA3 10501 Bourke – Cobar - Coonamble almost 30% of the population;
- SA3 10801 Great lakes had the highest assisted needs proportion almost 9% of the population; and
- SA3 12501 Auburn had the highest population portion with no or little English 18.4%;
- 11603 Mount Druitt has the lowest population portion with non-admitted Medicare subsidised Out-of-pocket Costs 18.5%, 12104 North Sydney –Mosman the highest 76.2%.

Table 18 Summary table of independent / explanatory variables to be tested in the HORSt regression analysis by NSW SA3 area

SA3 Code and Name	IRSD	IRSAD	IER	IEO	ARIA	% of pop ATSI	% of pop Assisted Needs	% of pop No or Poor English	Lone person households	% Out of pocket costs ALL	% Out of pocket costs GPs	% Out of pocket costs Specialists	% Out of pocket costs Diagnostics & Imaging
10101 Goulburn – Yass	982.6	970.4	1007.4	968.9	2	3.02%	6.41%	0.40%	7247	58.35%	44.10%	73.20%	29.45%
10102 Queanbeyan	1053.4	1056.3	1059.4	1045.1	2	3.02%	3.84%	1.28%	5264	68.30%	61.60%	75.40%	39.10%
10103 Snowy Mountains	1004.9	980.9	998.8	985.0	4	2.39%	4.43%	0.43%	2242	60.90%	48.10%	75.40%	20.30%
10104 South Coast	968.8	943.6	975.7	953.8	4	4.69%	6.92%	0.29%	8695	62.40%	47.90%	76.30%	32.20%
10201 Gosford	1013.1	1005.0	1014.4	1007.9	1	2.58%	5.79%	0.54%	16968	56.00%	33.80%	78.60%	31.90%
10202 Wyong	962.1	943.6	985.7	929.9	0	4.28%	7.12%	0.44%	14987	50.00%	25.50%	75.30%	28.70%
10301 Bathurst	984.1	970.8	994.6	973.0	2	4.81%	4.93%	0.32%	4395	50.80%	30.70%	67.80%	36.30%
10302 Lachlan Valley	941.4	928.5	968.0	938.2	5	9.21%	6.29%	0.22%	6269	47.30%	24.70%	72.20%	24.10%
10303 Lithgow - Mudgee	942.3	926.0	971.8	912.4	3	4.98%	5.89%	0.33%	5233	46.50%	25.10%	69.70%	20.80%
10304 Orange	988.5	977.1	1001.0	975.4	2	5.40%	5.24%	0.55%	5618	56.20%	38.30%	71.80%	39.60%
10401 Clarence Valley	926.0	907.4	953.3	917.9	3	6.67%	8.41%	0.21%	5679	61.50%	37.00%	75.00%	44.00%
10402 Coffs Harbour	966.7	953.6	973.6	964.4	4	4.59%	6.16%	0.77%	8776	53.60%	37.50%	76.40%	15.10%
10501 Bourke - Cobar - Coonamble	892.1	902.1	916.4	940.9	11	29.45%	5.16%	0.42%	2808	27.70%	11.10%	47.50%	23.10%
10502 Broken Hill and Far West	897.9	889.0	917.4	903.2	11	12.04%	7.47%	0.36%	2817	25.90%	16.00%	25.60%	9.40%
10503 Dubbo	953.7	942.4	975.6	950.2	5	16.15%	6.00%	0.27%	6768	46.70%	26.70%	58.50%	36.40%
10601 Lower Hunter	949.1	929.4	987.9	897.9	2	5.04%	6.36%	0.24%	7338	50.70%	33.90%	74.50%	15.00%
10602 Maitland	989.5	972.2	1009.9	946.7	0	3.82%	5.66%	0.35%	5705	60.80%	48.70%	76.00%	19.90%
10603 Port Stephens	978.4	957.3	998.6	938.6	1	4.17%	6.48%	0.30%	6639	51.20%	32.00%	71.70%	18.60%
10604 Upper Hunter	951.5	936.1	983.2	905.2	4	5.49%	4.81%	0.40%	3009	52.30%	34.50%	71.90%	23.20%
10701 Dapto - Port Kembla	949.2	938.8	977.4	919.7	0	3.20%	7.57%	3.39%	6402	39.20%	11.90%	69.90%	14.60%
10703 Kiama - Shellharbour	996.7	981.0	1016.3	959.2	1	3.05%	6.19%	1.20%	6517	44.30%	17.70%	74.30%	20.50%
10704 Wollongong	1012.3	1020.2	988.8	1042.3	0	2.00%	5.75%	2.45%	12469	52.90%	29.80%	74.90%	21.50%
10801 Great Lakes	930.1	910.3	956.0	918.4	2	4.57%	8.75%	0.24%	4109	60.00%	37.00%	79.80%	19.30%
10802 Kempsey - Nambucca	895.4	884.4	935.4	901.6	4	11.05%	8.43%	0.21%	5574	46.40%	23.60%	73.20%	16.90%
10804 Port Macquarie	975.9	958.0	985.2	964.7	3	3.85%	7.38%	0.20%	8815	50.00%	17.10%	79.60%	32.20%
10805 Taree - Gloucester	922.1	907.1	951.3	916.9	3	6.16%	7.89%	0.24%	6037	59.30%	38.60%	78.10%	19.00%
10901 Albury	973.7	957.7	969.0	963.3	2	2.62%	5.88%	0.66%	6955	61.90%	49.50%	77.50%	26.00%
10902 Lower Murray	951.9	937.9	973.5	940.3	7	9.57%	5.03%	0.55%	1275	48.30%	24.10%	65.60%	32.20%
10903 Upper Murray exc. Albury	968.6	946.9	979.5	945.7	4	2.74%	5.88%	0.26%	5031	64.10%	47.80%	80.90%	19.40%
11001 Armidale	985.9	979.3	969.5	1015.0	4	7.38%	5.09%	0.66%	3814	58.60%	46.40%	70.80%	38.40%

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Table 18– continued

SA3 Code and Name	IRSD	IRSAD	IER	IEO	ARIA	% of pop ATSI	% of pop Assisted Needs	% of pop No or Poor English	Lone person households	% Out of pocket costs ALL	% Out of pocket costs GPs	% Out of pocket costs Specialists	% Out of pocket costs Diagnostics & Imaging
11002 Inverell - Tenterfield	914.0	906.0	947.7	929.0	5	7.44%	6.73%	0.28%	4509	54.60%	40.60%	72.50%	33.20%
11003 Moree - Narrabri	939.0	932.1	958.9	937.3	6	19.04%	4.25%	0.33%	2529	52.90%	43.80%	65.60%	15.60%
11004 Tamworth - Gunnedah	955.3	941.3	977.5	936.9	4	10.52%	5.65%	0.25%	8241	61.60%	51.70%	72.10%	35.60%
11101 Lake Macquarie - East	1001.4	986.5	1004.6	977.4	0	3.04%	6.24%	0.45%	11256	58.80%	42.90%	72.20%	18.00%
11102 Lake Macquarie - West	984.2	965.0	1003.9	948.3	0	4.05%	7.28%	0.37%	6213	51.60%	32.50%	72.20%	17.40%
11103 Newcastle	993.6	992.7	966.5	1012.6	0	3.15%	5.99%	1.22%	18245	61.60%	49.40%	71.10%	22.50%
11201 Richmond Valley - Coastal	997.9	988.6	993.2	1013.2	1	3.04%	5.45%	0.33%	8400	64.80%	47.30%	76.90%	25.00%
11202 Richmond Valley -	933.6	921.5	953.5	937.4	2	6.11%	6.89%	0.41%	7729	61.60%	46.20%	71.50%	39.40%
11203 Tweed Valley	973.3	956.3	984.9	959.5	1	4.02%	7.14%	0.37%	10106	52.10%	30.70%	71.40%	23.20%
11301 Griffith - Murrumbidgee	954.6	939.1	974.4	922.3	6	6.79%	5.42%	2.14%	4341	57.30%	40.10%	71.00%	31.40%
11302 Tumut - Tumbarumba	951.1	933.4	977.9	927.0	3	4.62%	4.89%	0.37%	1575	44.70%	16.80%	84.60%	35.00%
11303 Wagga Wagga	983.6	966.4	989.1	966.2	3	5.00%	5.31%	0.53%	9129	59.30%	41.90%	81.80%	47.10%
11401 Shoalhaven	963.6	943.1	981.6	949.2	2	5.50%	7.68%	0.36%	10895	56.60%	37.00%	70.20%	22.50%
11402 Southern Highlands	1034.6	1021.8	1046.0	1024.8	1	2.09%	5.64%	0.31%	4642	61.60%	47.50%	71.70%	32.00%
11501 Baulkham Hills	1106.2	1133.9	1128.1	1113.9	0	0.34%	3.72%	2.93%	5613	50.50%	27.30%	79.60%	20.20%
11502 Dural - Wisemans Ferry	1091.4	1104.0	1137.4	1073.0	1	0.60%	4.25%	1.33%	1111	58.50%	34.10%	83.60%	29.40%
11503 Hawkesbury	1061.7	1049.5	1108.8	1005.9	2	2.03%	3.65%	0.30%	1199	51.00%	27.60%	78.80%	18.10%
11504 Rouse Hill - McGraths Hill	1098.4	1116.7	1154.8	1059.2	0	1.01%	2.80%	1.23%	976	43.30%	18.00%	77.40%	15.10%
11601 Blacktown	984.9	986.5	989.1	971.0	0	2.32%	5.46%	4.92%	7628	27.70%	5.60%	60.00%	6.70%
11602 Blacktown - North	1076.8	1096.6	1117.6	1051.5	0	1.57%	3.28%	2.49%	2767	34.80%	9.60%	72.30%	11.00%
11603 Mount Druitt	913.1	916.3	951.5	896.0	0	5.37%	6.23%	4.42%	5083	18.50%	2.60%	49.20%	3.30%
11701 Botany	1001.2	1028.5	967.9	1028.4	0	1.85%	4.90%	5.86%	3783	40.80%	19.00%	67.70%	17.30%
11702 Marrickville - Sydenham -	1034.8	1078.0	979.4	1101.6	0	1.91%	5.05%	7.13%	5511	47.90%	28.90%	68.70%	20.30%
11703 Sydney Inner City	1028.2	1096.2	884.6	1149.6	0	1.66%	2.44%	3.68%	32415	53.90%	39.10%	71.80%	27.30%
11801 Eastern Suburbs - North	1101.6	1151.3	1031.5	1174.5	0	0.39%	2.78%	1.26%	14082	68.90%	54.30%	81.00%	42.00%
11802 Eastern Suburbs - South	1051.7	1095.5	983.6	1118.5	0	1.73%	3.81%	3.27%	13098	52.10%	32.10%	71.70%	23.10%
11901 Bankstown	941.1	963.9	971.3	966.3	0	0.92%	7.03%	9.36%	10163	32.20%	9.50%	65.40%	7.00%
11902 Canterbury	930.8	958.2	943.1	966.6	0	0.55%	6.27%	13.45%	7681	28.80%	6.70%	62.10%	7.00%
11903 Hurstville	1007.0	1032.3	992.1	1039.8	0	0.70%	5.24%	8.84%	8582	42.40%	19.40%	70.90%	13.10%
11904 Kogarah - Rockdale	1005.6	1027.0	976.9	1032.3	0	0.63%	5.29%	7.52%	10594	40.00%	14.80%	70.70%	15.00%

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Table 18– continued

SA3 Code and Name	IRSD	IRSAD	IER	IEO	ARIA	% of pop ATSI	% of pop Assisted Needs	% of pop No or Poor English	Lone person households	% Out of pocket costs ALL	% Out of pocket costs GPs	% Out of pocket costs Specialists	% Out of pocket costs Diagnostics & Imaging
12001 Canada Bay	1070.8	1108.6	1026.1	1121.0	0	0.45%	4.26%	4.49%	6944	51.90%	25.60%	76.30%	23.60%
12002 Leichhardt	1089.7	1142.1	1041.6	1169.1	0	1.19%	3.40%	1.87%	6102	63.10%	45.70%	78.00%	34.40%
12003 Strathfield - Burwood -	1023.5	1059.9	966.3	1083.8	0	0.68%	4.82%	8.45%	11696	38.20%	15.60%	67.60%	12.30%
12101 Chatswood - Lane Cove	1092.7	1142.0	1047.7	1162.3	0	0.24%	3.28%	4.23%	9277	60.10%	43.80%	81.60%	40.40%
12102 Hornsby	1079.4	1101.1	1065.4	1106.1	0	0.51%	3.89%	3.66%	5099	54.80%	33.80%	81.90%	41.30%
12103 Ku-ring-gai	1121.0	1166.6	1110.2	1169.7	0	0.16%	3.63%	2.31%	6161	67.10%	51.70%	85.20%	49.40%
12104 North Sydney - Mosman	1110.1	1160.7	1025.9	1192.9	0	0.22%	2.41%	1.49%	13539	76.20%	67.70%	84.50%	55.20%
12201 Manly	1110.7	1158.7	1077.0	1169.2	0	0.34%	2.43%	0.92%	3678	73.60%	61.00%	85.40%	44.90%
12202 Pittwater	1100.5	1120.5	1074.1	1108.4	0	0.51%	3.68%	0.60%	4127	72.70%	60.80%	87.00%	46.80%
12203 Warringah	1084.2	1109.0	1089.9	1094.5	0	0.49%	4.01%	1.78%	11328	64.40%	46.90%	83.00%	39.10%
12301 Camden	1055.2	1053.2	1100.9	1004.3	0	2.32%	4.50%	0.61%	2719	44.70%	19.80%	78.30%	12.70%
12302 Campbelltown (NSW)	951.3	948.5	977.6	932.3	0	3.80%	5.85%	2.87%	9237	29.00%	5.60%	66.30%	7.00%
12303 Wollondilly	1039.2	1026.4	1088.8	976.5	0	2.86%	4.70%	0.42%	2036	41.00%	14.60%	75.60%	13.70%
12401 Blue Mountains	1045.3	1042.5	1038.6	1069.9	1	2.06%	5.50%	0.42%	7353	54.20%	30.10%	74.80%	9.40%
12403 Penrith	991.4	989.2	1025.0	953.1	0	2.83%	5.03%	1.06%	9064	35.20%	10.30%	70.70%	7.30%
12404 Richmond - Windsor	993.0	975.9	1012.1	946.1	0	4.38%	5.69%	0.66%	2928	48.10%	24.10%	76.80%	16.00%
12405 St Marys	964.6	948.7	989.5	905.1	0	3.74%	5.52%	2.38%	3192	25.70%	3.40%	62.80%	5.30%
12501 Auburn	936.7	979.1	930.9	986.7	0	0.72%	4.45%	14.80%	4443	23.30%	4.60%	58.80%	6.80%
12502 Carlingford	1033.8	1058.5	1023.9	1070.1	0	0.78%	4.73%	7.05%	4018	38.80%	15.90%	72.60%	17.20%
12503 Merrylands - Guildford	914.3	941.3	946.2	944.0	0	0.96%	6.65%	9.63%	8978	25.40%	4.70%	58.20%	7.20%
12504 Parramatta	1022.4	1040.9	963.5	1057.8	0	0.98%	4.69%	6.42%	10042	32.30%	9.50%	65.40%	12.30%
12601 Pennant Hills - Epping	1096.9	1133.1	1077.2	1144.7	0	0.29%	3.48%	4.67%	2435	51.40%	31.40%	80.90%	28.50%
12602 Ryde - Hunters Hill	1061.1	1093.1	1018.7	1113.0	0	0.39%	4.69%	5.64%	10927	48.90%	27.30%	76.80%	24.20%
12701 Bringelly - Green Valley	1033.8	1058.5	1023.9	1070.1	0	0.00%	5.62%	6.58%	3545	30.10%	6.00%	69.40%	7.50%
12702 Fairfield	860.9	899.9	949.1	883.9	0	0.81%	8.37%	18.40%	8078	26.70%	4.70%	62.10%	5.20%
12703 Liverpool	957.5	977.3	994.0	968.2	0	1.55%	6.36%	7.33%	6201	30.40%	6.60%	68.40%	6.90%
12801 Cronulla - Miranda -	1073.6	1083.6	1067.5	1067.6	0	0.95%	4.36%	1.23%	9804	57.60%	31.70%	82.60%	24.60%
12802 Sutherland - Menai -	1086.4	1091.5	1100.5	1063.3	0	0.91%	4.21%	1.01%	6212	58.30%	33.50%	83.10%	23.70%

(Australian Bureau of Statistics 2017a, 2017b, 2017c, 2017g, 2018a, 2018b).

5.6 CHAPTER SUMMARY OF DATA SOURCES APPLIED TO THE STUDY METHODOLOGY

This chapter has outlined and justified the data to be used to support the methodology outlined in Chapter Four for the development of the HORSt.

The HORSt benchmark methodology makes use of:

- 88 NSW SA3 populations defined by the ABS.
- The decision to use the SA3 populations is determined by the availability of MBS and PBS data at this level.
- Population health status is the DEA output variable and is measured by the transformed median rate of age-standardised and casemix adjusted (NWAUs) per 10,000 people for PPHs for the years 2013-14, 2014-15, 2015-16;
- The median age-standardised rates of MBS and PBS costs per 10,000 people for the years 2013-14, 2014-15, 2015-16, are DEA inputs representing Commonwealth government taxpayer funded inputs; and
- The median age-standardised and casemix (NWAUs) adjusted rate per 10,000 people (SCRs) is a DEA input representing state health administered taxpayer funded inputs.

The HORSt regression modelling methodology makes use of:

- The measured DEA allocative efficiency scores for the population health status of each NSW SA3 populations will be the dependent variable;
- Testing explanatory variables from the Australian 2016 census and reputable secondary data include:
    - The 4 ABS SEIFA variables IRSD, IRSAD, IER, IEO (in separate regression models) along with variables that: represent location (ARIA); the indigenous population; disability (portion of people requiring assistance); people with poor levels of English proficiency; the number of people living alone; and ability to pay out-of-pocket costs.

CHAPTER SIX – RESULTS

6.0 INTRODUCTION

This chapter presents the results for the HORSt. Aligned with the previous methodology chapter the results are organised into three sections. These are:

1. The DEA allocative efficiency scores of the SA3 populations;
2. The regression analysis that identifies variables that predict the allocative efficiency scores of the SA3 populations'; and
3. The vertical equity adjusted needs-based shares for SA3 populations and ultimately the LHNs that can be used to guide resource allocation decisions between the NSW state government and regions.

6.1 DEA RESULTS

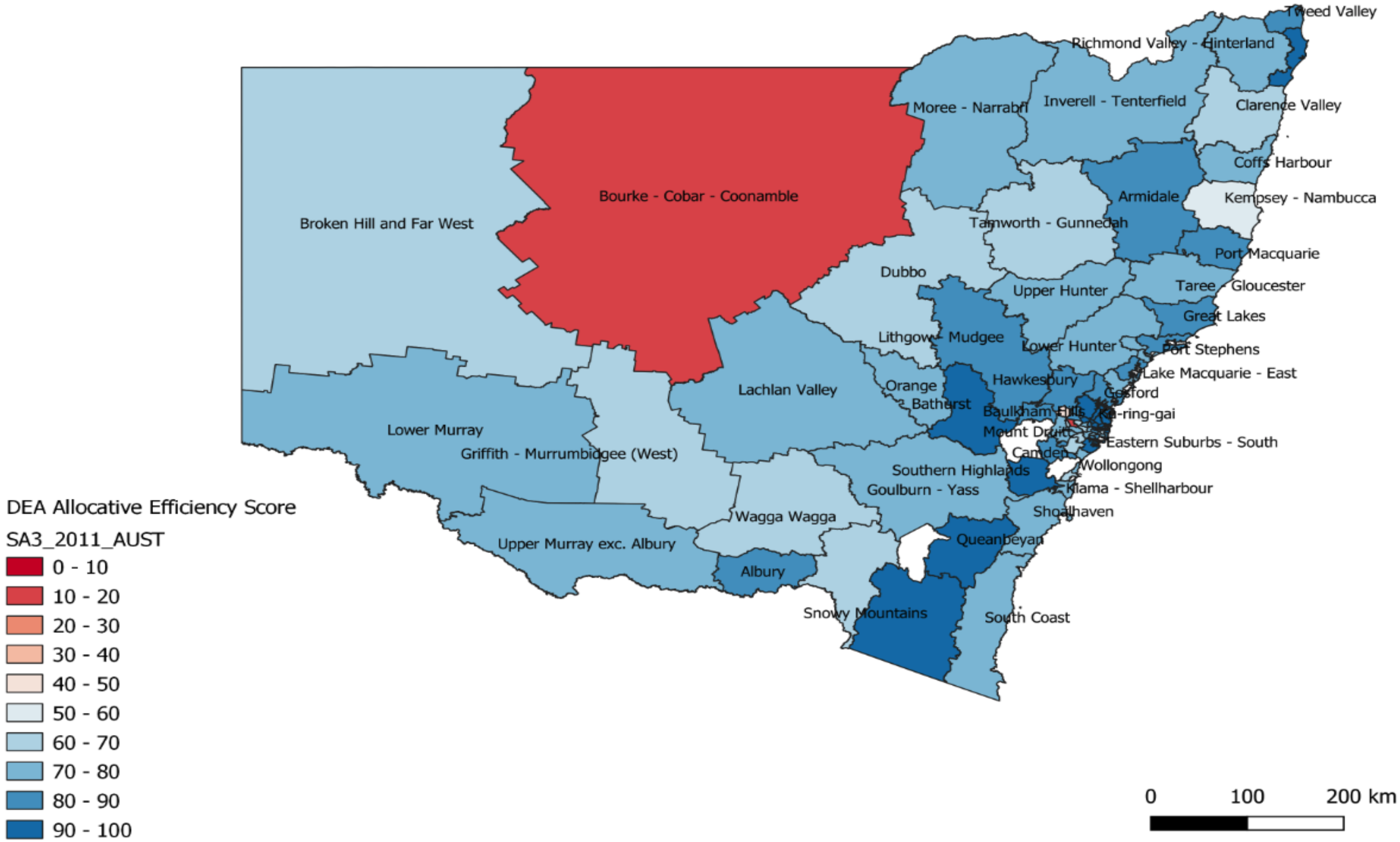
The DEA allocative efficiency scores for each DMU / SA3 are summarised in Table 19. Heat maps for these scores are shown for NSW and the metropolitan and surrounding areas of Sydney in figures 27 and 28 respectively. A descriptive analysis is also provided for these results, where the DEA efficiency scores are the dependent variable in the regression analysis. As outlined in Chapter Four there is no requirement for the data of the dependent variable to be normally distributed to support the regression, the requirement is for the standardized regression residuals for the dependent variable to be normal. The distribution shown for the data in Figure 29 shows extremely low scores of two DMUs below 20 are clearly visible. These are for the SA3 areas Bourke – Cobar – Coonamble and Mount Druitt having scores of 11.13 and 15.08 respectively. Figure 30 shows a stem and leaf plot. Both areas are known to have very poor health outcomes and challenging social determinants that give rise to these outcomes (Centre for Epidemiology and Evidence 2018; Centre for Epidemiology and Research 2010; McNab & Gillespie 2015; Western NSW Local Health District & Western NSW Medicare Local 2013).

Assessment of the DEA scores is conducted by considering the top and bottom 5 ranked DMUs / SA3 populations in terms of their allocative efficiency scores and with respect to their ranked health status that was used as the DEA output and their ranked use of input resources. Table 20 shows a summary of the efficiency scores compared to ranked health status, Table 21 shows a summary compared to ranked resource intensity.

Table 19 Summary of DEA Allocative Efficiency Scores for the 88 DMUs / SA3 NSW populations

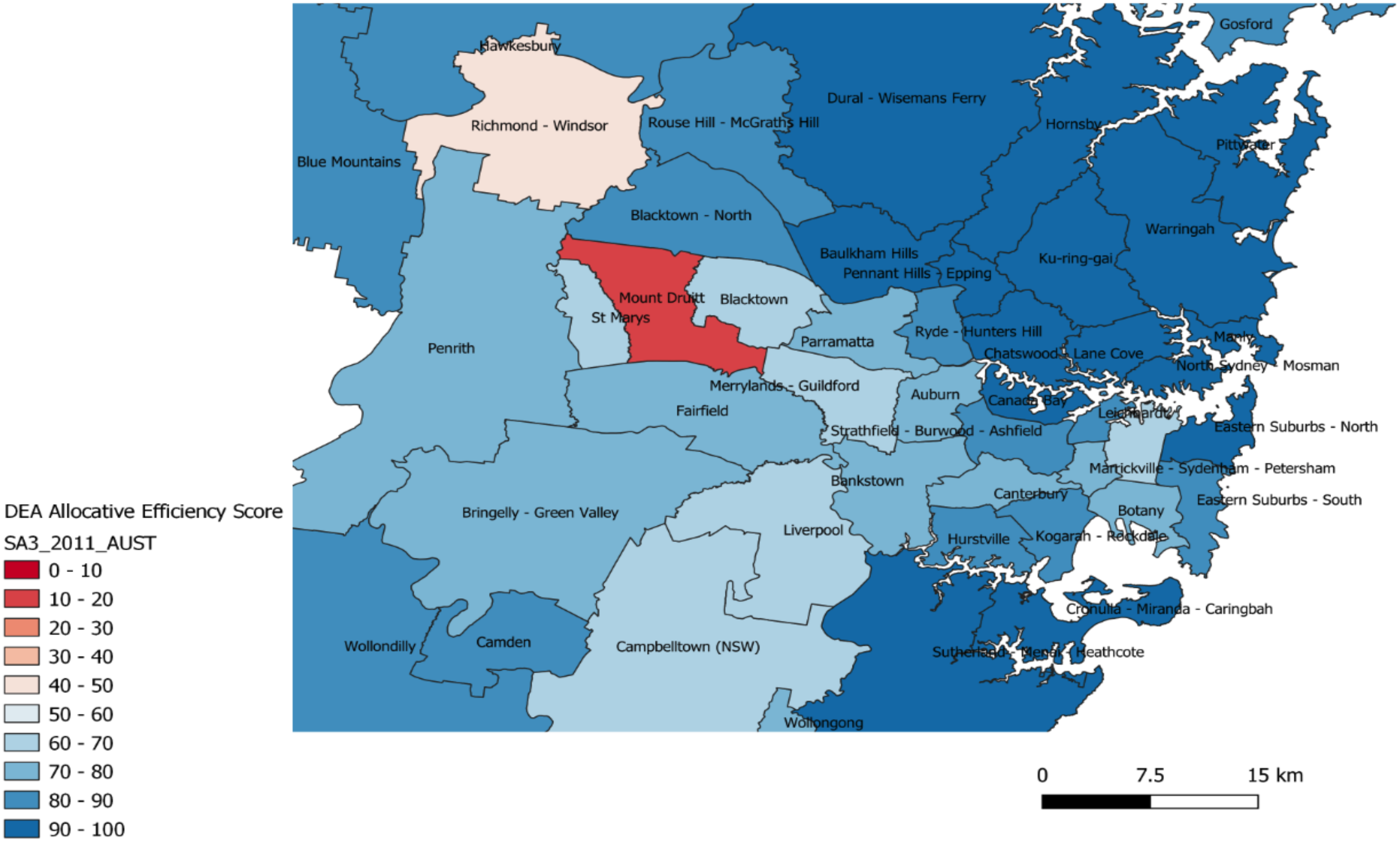
DMU/SA3 Code and Name	DEA Allocative Efficiency Scores	DMU/SA3 Code and Name	DEA Allocative Efficiency Scores
10101 Goulburn – Yass	70.21	11501 Baulkham Hills	97.34
10102 Queanbeyan	90.7	11502 Dural - Wisemans Ferry	96.23
10103 Snowy Mountains	100	11503 Hawkesbury	86.68
10104 South Coast	74.26	11504 Rouse Hill - McGraths Hill	88.47
10201 Gosford	88.79	11601 Blacktown	61.64
10202 Wyong	76.12	11602 Blacktown - North	80.93
10301 Bathurst	93.9	11603 Mount Druitt	15.08
10302 Lachlan Valley	70.09	11701 Botany	79.35
10303 Lithgow - Mudgee	82.64	11702 Marrickville - Sydenham - Petersham	76.76
10304 Orange	79.25	11703 Sydney Inner City	68.99
10401 Clarence Valley	63.83	11801 Eastern Suburbs - North	91.3
10402 Coffs Harbour	70.66	11802 Eastern Suburbs - South	85.33
10501 Bourke - Cobar - Coonamble	11.13	11901 Bankstown	73.61
10502 Broken Hill and Far West	69.12	11902 Canterbury	70.73
10503 Dubbo	67.6	11903 Hurstville	87.03
10601 Lower Hunter	74.07	11904 Kogarah - Rockdale	81.25
10602 Maitland	71.63	12001 Canada Bay	95.21
10603 Port Stephens	86.04	12002 Leichhardt	86.31
10604 Upper Hunter	73.46	12003 Strathfield - Burwood - Ashfield	87.74
10701 Dapto - Port Kembla	63.19	12101 Chatswood - Lane Cove	96.86
10703 Kiama - Shellharbour	73.85	12102 Hornsby	94.19
10704 Wollongong	74.99	12103 Ku-ring-gai	100
10801 Great Lakes	84.86	12104 North Sydney - Mosman	91.98
10802 Kempsey - Nambucca	55.74	12201 Manly	94.41
10804 Port Macquarie	81.65	12202 Pittwater	98.83
10805 Taree - Gloucester	78.52	12203 Warringah	93.98
10901 Albury	81.88	12301 Camden	89.36
10902 Lower Murray	71.53	12302 Campbelltown (NSW)	62.53
10903 Upper Murray exc. Albury	75.46	12303 Wollondilly	89.12
11001 Armidale	85.06	12401 Blue Mountains	85.22
11002 Inverell - Tenterfield	70.59	12403 Penrith	75.39
11003 Moree - Narrabri	70.94	12404 Richmond - Windsor	46.39
11004 Tamworth - Gunnedah	67.49	12405 St Marys	60.83
11101 Lake Macquarie - East	88.86	12501 Auburn	73.35
11102 Lake Macquarie - West	81.92	12502 Carlingford	86.38
11103 Newcastle	78.25	12503 Merrylands - Guildford	65.85
11201 Richmond Valley - Coastal	93.99	12504 Parramatta	73.61
11202 Richmond Valley - Hinterland	70.83	12601 Pennant Hills - Epping	100
11203 Tweed Valley	85.25	12602 Ryde - Hunters Hill	91.96
11301 Griffith - Murrumbidgee (West)	61.64	12701 Bringelly - Green Valley	76.34
11302 Tumut - Tumbarumba	60.71	12702 Fairfield	75.83
11303 Wagga Wagga	62.71	12703 Liverpool	68.07
11401 Shoalhaven	75.61	12801 Cronulla - Miranda - Caringbah	96.23
11402 Southern Highlands	91.84	12802 Sutherland - Menai - Heathcote	91.13

Figure 27 *Heat map of NSW DEA Allocative Efficiency Scores for the 88 DMUs / SA3 NSW populations*



Note –the legend above shows efficiency scores bound between 0 through to 100% clustered into deciles. Areas shaded in white are the ACT, and the SA3's excluded for very low populations (discussed on page 139).

Figure 28 *Heat map of NSW DEA Allocative Efficiency Scores for the metropolitan DMUs / SA3 NSW populations around Sydney*



Note –the legend above shows efficiency scores bound between 0 through to 100% clustered into deciles.

Figure 29 Histogram showing the distribution of DEA Allocative Efficiency Scores for the 88 DMUs / SA3 NSW populations

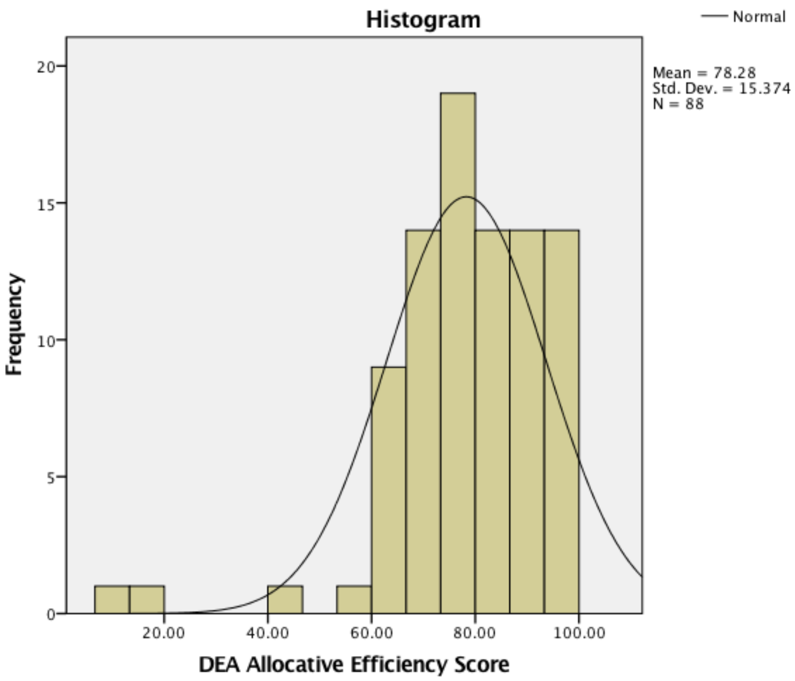


Figure 30 DEA Allocative Efficiency Scores Stem-and-Leaf Plot

```
Frequency    Stem &  Leaf

   2.00 Extremes    (=<15)
   1.00        4 .  6
   1.00        5 .  5
  14.00        6 .  00112233577889
  28.00        7 .  0000000113333344455556668899
  22.00        8 .  0111124555566667788899
  17.00        9 .  01111133344566678
   3.00       10 .  000

Stem width:     10.00
Each leaf:       1 case(s)
```

Table 20   Highest and Lowest ranked DEA Allocative Efficiency Scores and health status (DEA output)

DEA Results - Highest and Lowest Efficiency					DEA Output and Health Status ranking for each DMU / SA3 highest (1) to lowest (88)		
Extreme Values	Rank	Case Number	DMU/SA3 Code and Name	DEA Allocative Efficiency Score	DEA Transformed Output	ACSCs age standardised NWAUs per 10k people	Health status ranking: (from best to worst health status as measured by the ACSCs rate and DEA Transformed output)
Highest	Eq 1	3	10103 Snowy Mountains	100	445	155	4
	Eq 1	66	12103 Ku-ring-gai	100	451	149	1
	Eq 1	82	12601 Pennant Hills - Epping	100	446	154	2
	4	69	12202 Pittwater	98.83	445	155	3
	5	45	11501 Baulkham Hills	97.34	439	161	5
Lowest	1	13	10501 Bourke - Cobar - Coonamble	11.13	50	550	88
	2	51	11603 Mount Druitt	15.08	68	532	87
	3	76	12404 Richmond - Windsor	46.39	209	391	86
	4	24	10802 Kempsey - Nambucca	55.74	251	349	85
	5	41	11302 Tumut - Tumbarumba	60.71	273	327	83

Table 21   Highest and Lowest ranked DEA Allocative Efficiency Scores and DEA resource inputs

DEA Results - Highest and Lowest Efficiency					DEA Input Resources ranked for each DMU / SA3 from highest (1) to lowest (88)					
Extreme Values	Rank	Case Number	DMU/SA3 Code and Name	DEA Allocative Efficiency Score	MBS $ age std per 10K	MBS $ Ranking	PBS $ age std per 10K	PBS $ Ranking	SCR (NWAUs) age std per 10K	SCR Ranking
Highest	Eq 1	3	10103 Snowy Mountains	100	4,282	88	1,827	88	2,259	86
	Eq 1	66	12103 Ku-ring-gai	100	10,007	22	3,042	79	2,243	87
	Eq 1	82	12601 Pennant Hills - Epping	100	9,594	34	3,126	78	2,069	88
	4	69	12202 Pittwater	98.83	9,301	43	2,975	80	2,652	71
	5	45	11501 Baulkham Hills	97.34	10,413	10	3,223	75	2,303	85
Lowest	1	13	10501 Bourke - Cobar - Coonamble	11.13	9,103	52	4,331	22	4,710	1
	2	51	11603 Mount Druitt	15.08	10,158	16	4,271	30	4,561	2
	3	76	12404 Richmond - Windsor	46.39	9,577	36	4,268	31	3,336	24
	4	24	10802 Kempsey - Nambucca	55.74	9,363	41	4,862	3	4,040	4
	5	41	11302 Tumut - Tumbarumba	60.71	8,689	66	4,242	33	3,434	18

As outlined in Chapter Four, the DEA allocative efficiency scores are relative to the output and input variables. Within an output orientated DEA model like the HORSt, it is reasonable to expect that the areas that have the best and worst outputs would be somewhat ranked towards the top and bottom extremes of the DEA scores, subject of course to their input resource usage compared to the other areas. Tables 20 and 21 indicate that the DEA results make intuitive sense when the five highest and lowest ranked allocative efficiency scores of DMUs are considered alongside the health status of these populations (their DEA output) and their corresponding taxpayer provided resource usage (their DEA inputs). Moreover, the DEA results are reasonably consistent with the underlying health status and social determinants of these populations that are routinely monitored by health authorities. The lowest 5 have some of the worst outcomes and challenging social determinants. The reverse is true for the top 5 (Australian Bureau of Statistics 2017e, 2017f, 2017h, 2018a, 2018b;

Centre for Epidemiology and Evidence 2018; Centre for Epidemiology and Research 2010; McNab & Gillespie 2015; Western NSW Local Health District & Western NSW Medicare Local 2013).

In terms of the DEA output, Table 20 shows that the DMUs / SA3s that have the five highest ranking DEA allocative efficiency scores also were the five best ranked areas for health status as measured by the five lowest rates of age-standardised and casemix adjusted PPHs (NWAUs) per 10,000 people and highest transformed DEA output variable. By contrast, the five lowest ranked DEA allocative efficiency scores belong to areas that occupy the bottom four and sixth worst ranked areas for health status.

Table 21 shows the underlying rankings of DEA input resource contributions to the DEA efficiency results and reinforce the logic of the DEA results. The top 3 DMUs; Snowy Mountains; Ku-ring-gai; Pennant Hills Epping; all being efficient (allocative efficiency = 100%). A contributing factor for these top three efficiency scores were not only did that they had the best outputs (health status) as per Table 19, they also used the least public inpatient hospital resources to do so. Furthermore, Snowy Mountains had also the lowest MBS and PBS resource usage. Ku-ring-gai and Pennant Hills Epping was somewhat different however, having higher ranked rates of MBS resource usage 22nd and 34th highest respectively, although their PBS resource usage ranked 79th and 78th respectively is the 9th and 10th lowest for the state.

Table 21 also shows that the two lowest areas for allocative efficiency; Bourke – Cobar – Coonamble and Mount Druitt had the two highest rates of age-standardised inpatient public hospital resource usage of the state (ranking 1 and 2) and at the same time had relative lower rates of MBS and PBS resource usage. These results also reinforce the logic of the DEA results. The technical efficiency contribution of these relatively high public hospital inputs to the allocative efficiency of these populations' health status appears to be somewhat ineffectual. However, the state provided hospital resource input contribution cannot be considered on its own. The appropriate mix of resources across the continuum of care for these populations may well be sub optimal and being compromised by access to private primary care, compromising the observed allocative efficiency. For example, the MBS usage for Bourke – Cobar – Coonamble is the 52nd lowest for the state.

With the DEA results making intuitive sense relative to the DEA output and inputs, the second stage of the DEA, the predictive regression modelling as outlined in Chapter Three can proceed. This is now discussed.

6.2 REGRESSION ANALYSIS

A matrix of Pearson's bi-variate correlations was initially produced to assess whether or not the independent variables identified in chapter five had a linear relationship with the dependent variable; the DEA allocative efficiency scores. Doing so follows a reductionist methodology to eliminate variables that will not be useful for the regression.

The matrix shown in Table 22 is also useful at providing preliminary indications of possible multicollinearity between independent variables where the correlation between independent variables are high. Correlations range between 0 and 1, 1 representing a perfect correlation.

The results indicate variables that do not have a significantly linear relationship with the dependent variable and these will be eliminated from the analysis. Shown in the shaded section of Table 22, these are:

- The proportion of the population that has No English and or poor English proficiency; and
- Lone person households.

A summary of the variables found to have a significant linear relationship with the dependent variable, listed in order of absolute value of strength of the correlation is as follows:

1. Index of Relative Socioeconomic Disadvantage (IRSD) 0.691;
2. Index of Relative Socioeconomic Advantage / Disadvantage (IRSAD) 0.638;
3. The portion of the population that are indigenous Australians (ATSI) -0.607 (a negative relationship);
4. Index of Education and Occupation (IEO) 0.602;
5. Index of Economic Resources (IER) 0.601;
6. Out-of-pocket costs Specialists 0.586;
7. Out-of-pocket costs ALL (includes GPs, Specialists, Diagnostics and Imaging and Obstetrics) 0.519;
8. Out-of-pocket costs GPs 0.425;
9. The portion of the population that are living with a disability and require assistance (Assisted Needs) -0.412 (a negative relationship);
10. Geographical location measured by the accessibility and remoteness index (ARIA) -0.406 (a negative relationship); and
11. Out-of-pocket costs Diagnostics and Imaging 0.320.

Table 22 Correlations Matrix – HORSt dependent variable and independent variables

Correlations Matrix		DEA Allocative Efficiency Score	IRSD	IRSAD	IER	IEO	Out of pocket costs ALL	Out of pocket costs GPs	Out of pocket costs Specialist	Out of pocket costs Diagnostics Imaging	Assist Need prop	No / Poor English prop	Lone person households	ATSI prop	ARIA
DEA Allocative Efficiency Score	Pearson Correlation	1	.691**	.638**	.601**	.602**	.519**	.425**	.586**	.320**	-.412**	-0.037	0.054	-.607**	-.406**
	Sig. (2-tailed)		0	0	0	0	0	0	0	0.002	0	0.73	0.618	0	0
IRSD	Pearson Correlation	.691**	1	.965**	.825**	.898**	.442**	.357**	.613**	.372**	-.802**	-0.105	0.066	-.568**	-.521**
	Sig. (2-tailed)	0		0	0	0	0	0.001	0	0	0	0.328	0.54	0	0
IRSAD	Pearson Correlation	.638**	.965**	1	.726**	.963**	.329**	.269*	.512**	.317**	-.829**	0.1	0.145	-.587**	-.561**
	Sig. (2-tailed)	0	0		0	0	0.002	0.011	0	0.003	0	0.352	0.179	0	0
IER	Pearson Correlation	.601**	.825**	.726**	1	.555**	.321**	.213*	.586**	.239*	-.579**	-0.198	-.297**	-.450**	-.416**
	Sig. (2-tailed)	0	0	0		0	0.002	0.046	0	0.025	0	0.065	0.005	0	0
IEO	Pearson Correlation	.602**	.898**	.963**	.555**	1	.369**	.330**	.457**	.384**	-.784**	0.128	.253*	-.513**	-.475**
	Sig. (2-tailed)	0	0	0	0		0	0.002	0	0	0	0.235	0.017	0	0
Out of pocket costs ALL	Pearson Correlation	.519**	.442**	.329**	.321**	.369**	1	.958**	.720**	.789**	-.247*	-.582**	0.149	-0.11	0.02
	Sig. (2-tailed)	0	0	0.002	0.002	0		0	0	0	0.02	0	0.166	0.314	0.857
Out of pocket costs GPs	Pearson Correlation	.425**	.357**	.269*	.213*	.330**	.958**	1	.554**	.764**	-.259*	-.539**	0.154	-0.02	0.11
	Sig. (2-tailed)	0	0.001	0.011	0.046	0.002	0		0	0	0.015	0	0.153	0.893	0.306
Out of pocket costs Specialist	Pearson Correlation	.586**	.613**	.512**	.586**	.457**	.720**	.554**	1	.527**	-.351**	-.312**	0.073	-.475**	-.412**
	Sig. (2-tailed)	0	0	0	0	0	0	0		0	0.001	0.003	0.502	0	0
Out of pocket costs Diagnostics Imaging	Pearson Correlation	.320**	.372**	.317**	.239*	.384**	.789**	.764**	.527**	1	-.315**	-.449**	0.1	0.044	0.144
	Sig. (2-tailed)	0.002	0	0.003	0.025	0	0	0	0		0.003	0	0.355	0.682	0.182
Assist Need prop	Pearson Correlation	-.412**	-.802**	-.829**	-.579**	-.784**	-.247*	-.259*	-.351**	-.315**	1	0.005	-0.022	.296**	.273*
	Sig. (2-tailed)	0	0	0	0	0	0.02	0.015	0.001	0.003		0.96	0.841	0.005	0.01
No / Poor English prop	Pearson Correlation	-0.037	-0.105	0.1	-0.198	0.128	-.582**	-.539**	-.312**	-.449**	0.005	1	0.111	-.369**	-.393**
	Sig. (2-tailed)	0.73	0.328	0.352	0.065	0.235	0	0	0.003	0	0.96		0.305	0	0
Lone person households	Pearson Correlation	0.054	0.066	0.145	-.297**	.253*	0.149	0.154	0.073	0.1	-0.022	0.111	1	-.213*	-.298**
	Sig. (2-tailed)	0.618	0.54	0.179	0.005	0.017	0.166	0.153	0.502	0.355	0.841	0.305		0.046	0.005
ATSI prop	Pearson Correlation	-.607**	-.568**	-.587**	-.450**	-.513**	-0.108	-0.015	-.475**	0.044	.296**	-.369**	-.213*	1	.828**
	Sig. (2-tailed)	0	0	0	0	0	0.314	0.893	0	0.682	0.005	0	0.046		0
ARIA	Pearson Correlation	-.406**	-.521**	-.561**	-.416**	-.475**	0.02	0.11	-.412**	0.144	.273*	-.393**	-.298**	.828**	1
	Sig. (2-tailed)	0	0	0	0	0	0.857	0.306	0	0.182	0.01	0	0.005	0	
** Correlation is significant at the 0.01 level (2-tailed).						N = 88 for all pairs									
* Correlation is significant at the 0.05 level (2-tailed).															

Table 22 Correlations matrix calculated using SPSS v24 software.

Figures 29 through 39 are scatter plots of the 11 independent variables that have a significant linear relationship with the dependent variable. For each correlation depicted the direction of association, positive or negative is shown, as well as simple regression R-squared coefficient of determination. As outlined in the methodology, the R-squared shows how much of the variation of the dependent variable is explained by independent variable. For these simple single variable regressions derived from each bi-variate correlation, the R-squared indicated is derived by squaring the independent variables' Pearson correlation coefficients.

Figure 31, 32, 33 and 34 illustrates that there is a *positive* linear relationship between the DEA allocative efficiency scores and the SEIFA variables IRSD, IRSAD, IER and IEO. When the value of these indices increases, which represents more advantageous socioeconomic status, the predicted value of the DEA allocative efficiency scores also increase and vice versa. This is consistent with the literature examined, whereby advantageous socioeconomic status is associated with better health outcomes and vice versa. Each of these SEIFA indices explains 47.8%, 40.7%, 36.1% and 36.3% respectively of the variation in DEA allocative efficiency scores.

Figure 31 Correlation relationship between DEA allocative efficiency scores and the IRSD

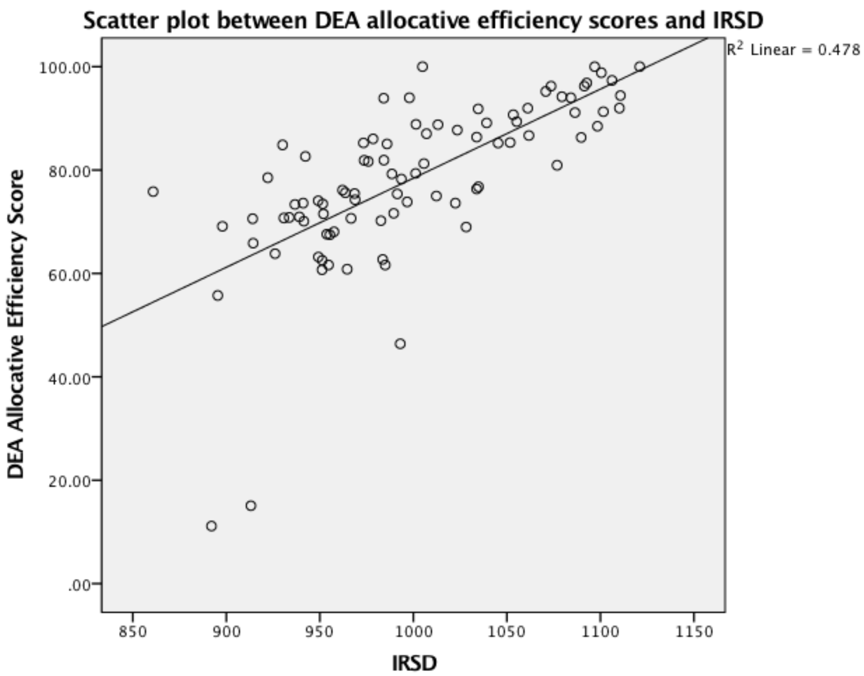


Figure 32 Correlation relationship between DEA allocative efficiency scores and the IRSAD

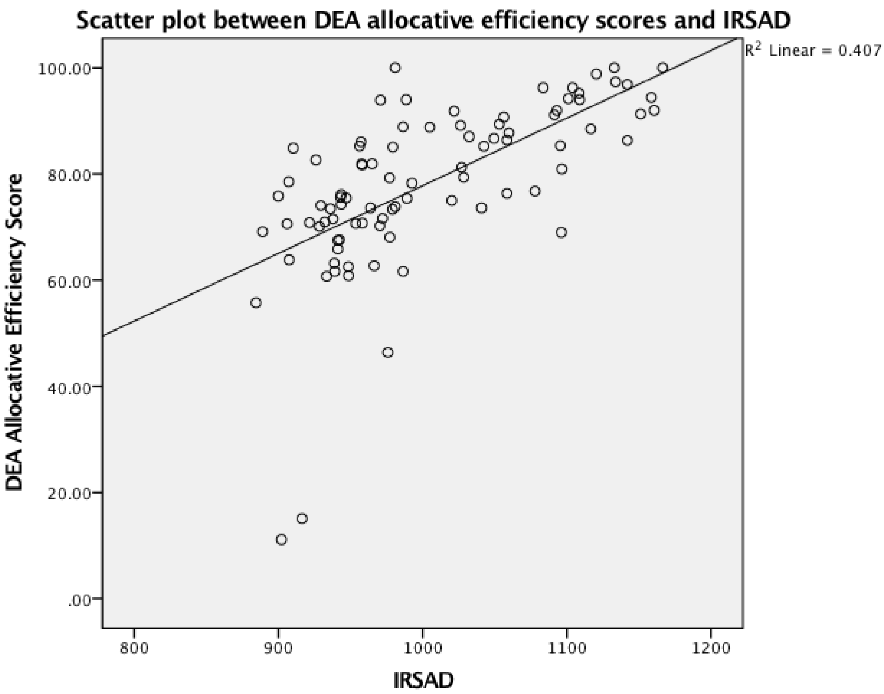


Figure 33 Correlation relationship between DEA allocative efficiency scores and the IER

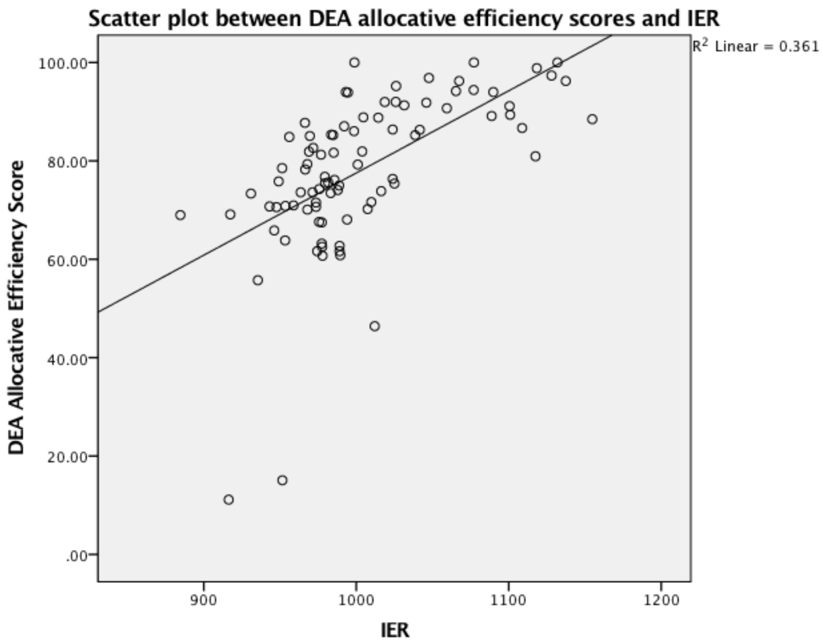
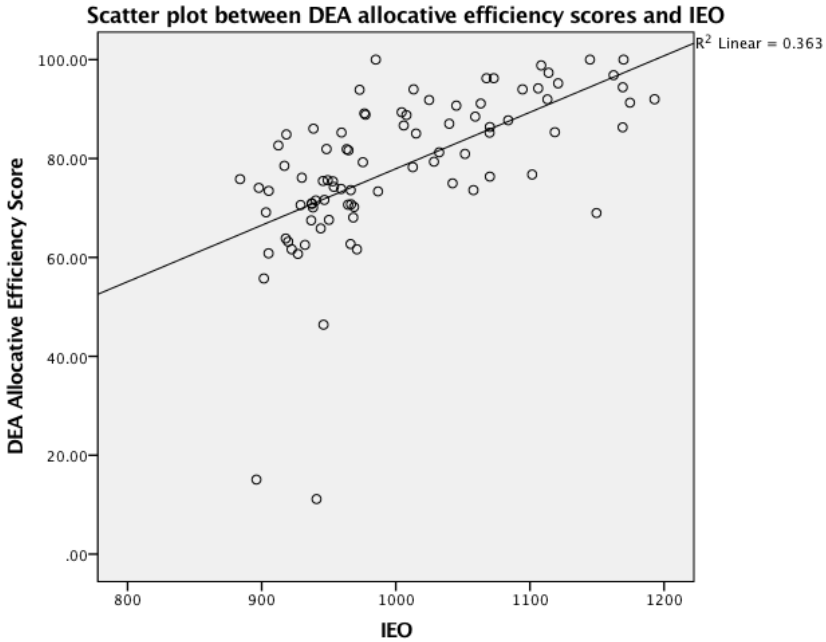


Figure 34 Correlation relationship between DEA allocative efficiency scores and the IEO



Figures 35 through 38 shows that the DEA allocative efficiency scores have a *positive* linear relationship with the percentage of patients with non-hospital / non-admitted Out-of-pocket costs. This is consistent with the underlying theory expressed in the methodology chapter that the expressed demand measured by the portion of patients with these out-of-pocket costs at the population level represents an affordability of access to private services, predominately primary care. Populations with a high percentage of patients that have paid out-of-pocket costs have by the nature of this expressed demand, a high percentage of patients accessing private primary care and the positive relationship of the correlation coefficients indicates that this high access is associated with higher DEA allocative efficiency scores. Contrastingly, populations with lower percentages of out-of-pocket costs exhibit lower DEA allocative efficiency scores.

Specifically, out-of-pocket costs for all non-admitted / non hospital categories explain 26.9% of the variation in the DEA efficiency scores. Non-admitted / non hospital out-of-pocket costs associated with GPs, Specialists and Diagnostic and Imaging services each explain 18%, 34.3% and 10.2% respectively of the variation in the DEA efficiency scores.

Figure 35 Correlation relationship between DEA allocative efficiency scores and all categories of Out-of-pocket Costs for non-admitted Medicare reimbursed services

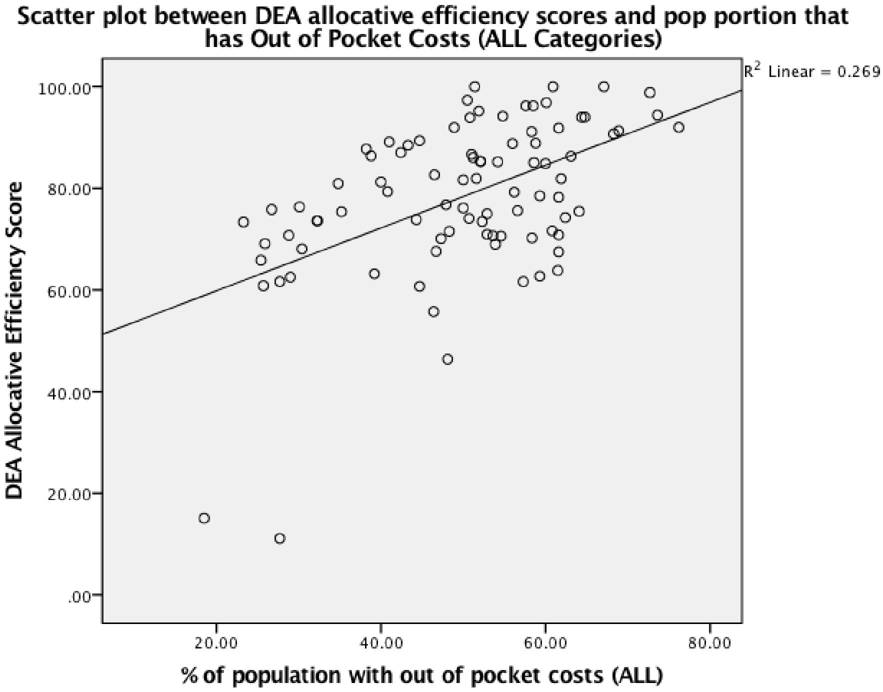


Figure 36 Correlation relationship between DEA allocative efficiency scores and GP Out-of-pocket Costs for non-admitted Medicare reimbursed services

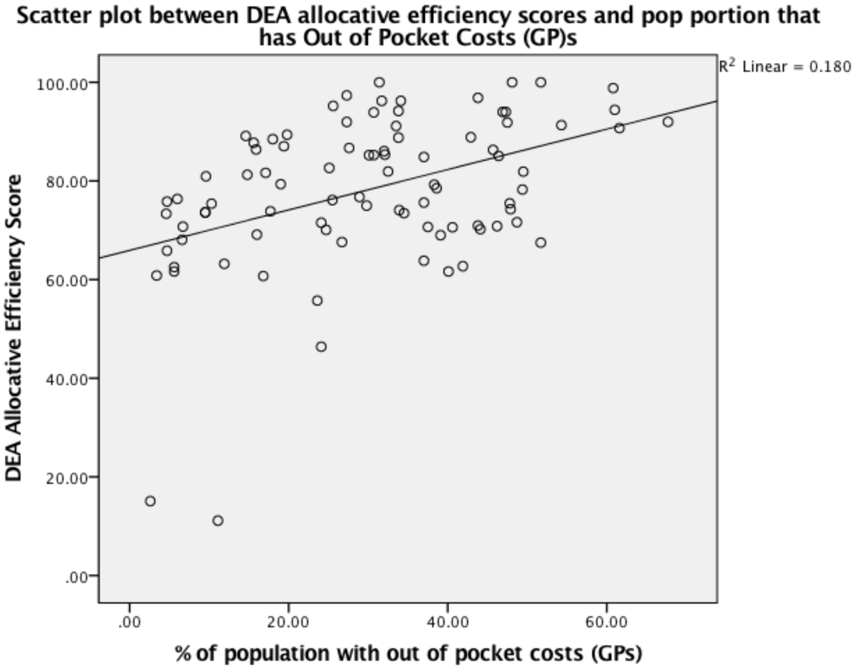


Figure 37 Correlation relationship between DEA allocative efficiency scores and Specialist Out-of-pocket Costs for non-admitted Medicare reimbursed services

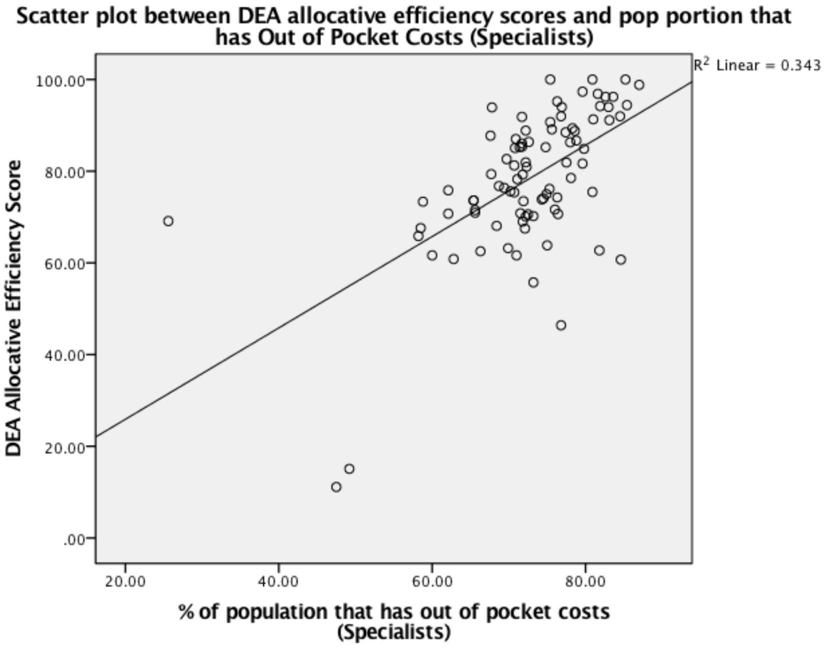


Figure 38 Correlation relationship between DEA allocative efficiency scores and Diagnostic and Imaging Out-of-pocket Costs for non-admitted Medicare reimbursed services

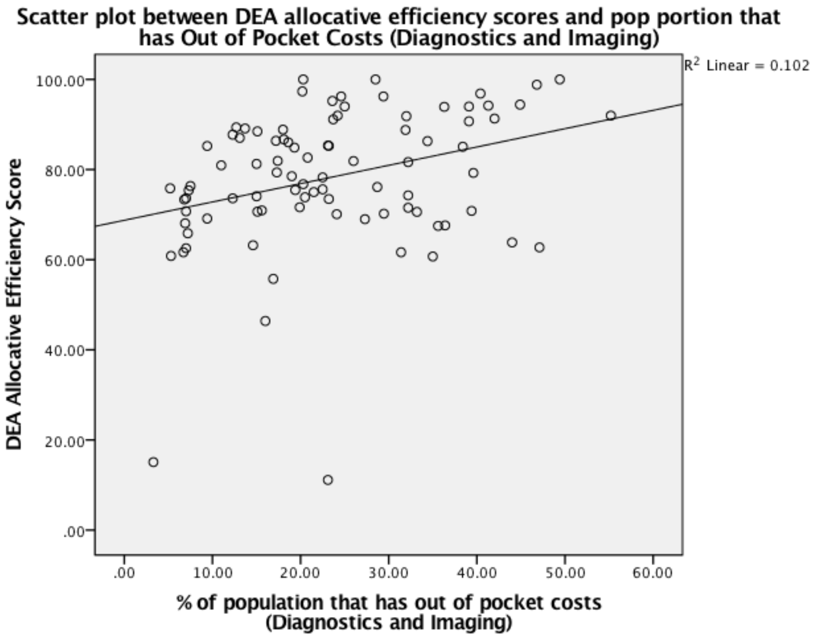


Figure 39 shows that the DEA allocative efficiency scores have a *negative* linear relationship with the percentage of the population living with a disability requiring assistance. This is congruent with the literature and underlying theory for this variable presented in the methodology chapter whereby higher portions of disability expressed through higher portions of the community requiring assisted needs correlate with lower rates of health status / health outcomes at the population level which in turn is associated with lower rates for allocative efficiency for those health outcomes. Specifically, the percentage of the population requiring assistance explains 17% of the variation in the DEA efficiency scores.

Figure 40 illustrates that the DEA allocative efficiency scores have a *negative* linear relationship with the percentage of the population that are indigenous Australians. This is aligned to the literature demonstrating the appalling health outcomes of indigenous Australians. At the population level higher percentages of indigenous Australians correlate with lower rates of health status / health outcomes which are associated with commensurate lower rates of allocative efficiency. Specifically, the percentage of the population that are indigenous Australians explains 36.8% of the variation in the DEA efficiency scores.

Figure 39 Correlation relationship between DEA allocative efficiency scores and the portion of the population that lives with a disability and requires assistance

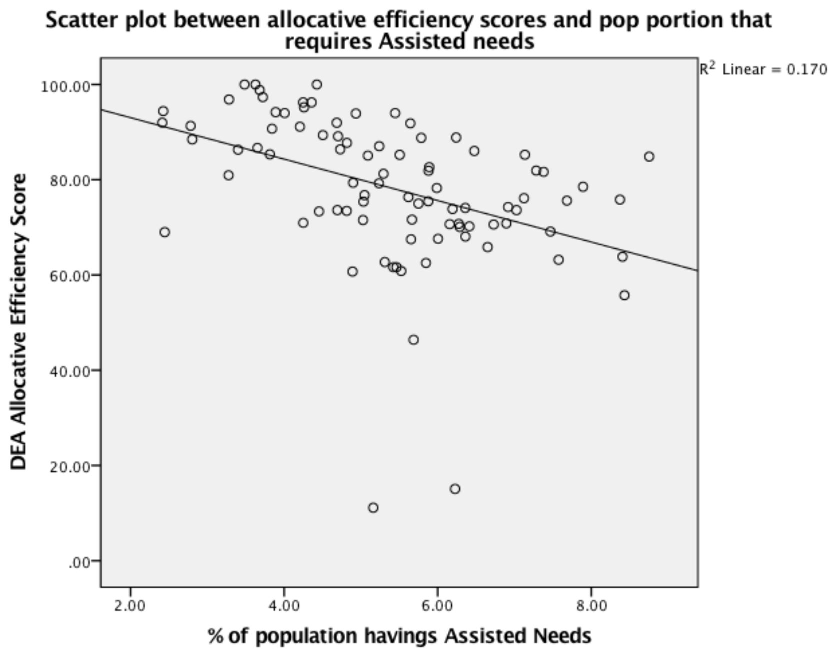


Figure 40 Correlation relationship between DEA allocative efficiency scores and the portion of the population that are indigenous Australians

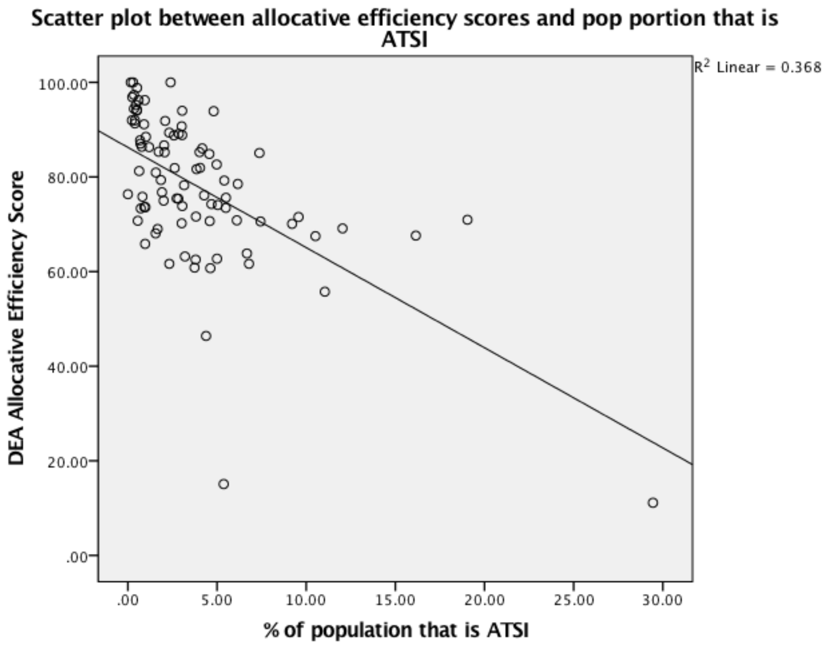
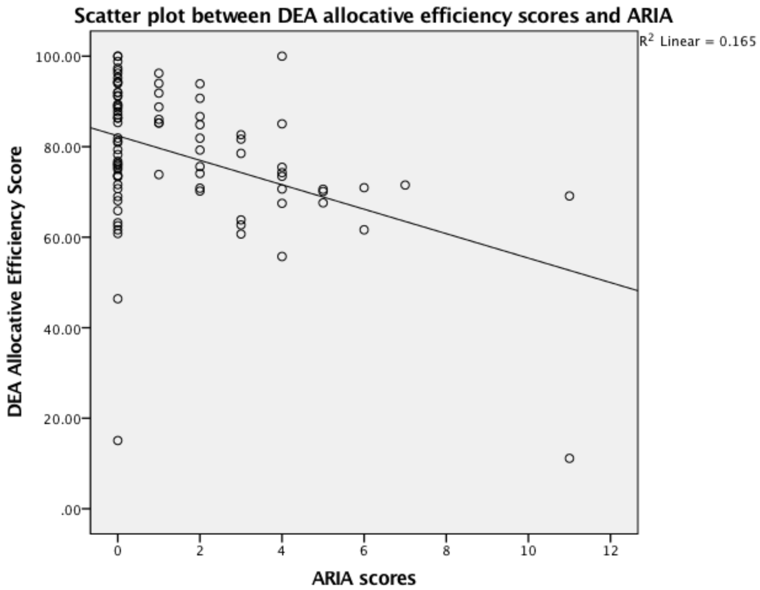


Figure 41 illustrates that the DEA allocative efficiency scores have a *negative* linear relationship with the Accessibility/Remoteness Index of Australia (ARIA). This too is aligned to the literature demonstrating that access issues in rural and remote areas to health services can compromise health outcomes. When the ARIA+ score is higher, indicating more remoteness and less access, the correlated DEA efficiency scores are lower and vice versa. Specifically, the ARIA score of populations explains 16.5% of the variation in the DEA efficiency scores.

Figure 41 Correlation relationship between DEA allocative efficiency scores and the Accessibility/Remoteness Index of Australia (ARIA+)



As outlined in the methodology chapter, the Pearson bi-variate correlations matrix (Table 22, page 198) provides guidance to the combinations of independent variables that should be considered in the regression analysis. For example, as discussed, to be somewhat expected is that all SEIFA indices show strong correlations amongst each other and therefore separate regression models containing a single SEIFA index will be assessed. Doing so will avoid an obvious problem of multicollinearity that would exist if multiple SEIFA indices were combined in a regression.

The correlation results also indicate potential multicollinearity problems with combining multiple independent variables of out-of-pocket expenses. Logically all out-of-pocket costs variable shows high correlations with that of out-of-pocket costs GPs, Specialists, Diagnostics and Imaging, having a correlation of 0.958, 0.720 and 0.789 respectively. For parsimony in the regression analysis the broadest category Out-of-pockets ALL (referred to as simply out-of-pocket costs for the remained of this thesis) will be utilised representing a broad potential financial barrier to private primary care.

Furthermore, there are potential multicollinearity problems with the strong correlation between the Assisted Needs variable and the IRSD, IRSAD and IER variables, having correlations of 0.802, 0.829 and 0.784 respectively. As outlined in the methodology section the IRSD and IRSAD SEIFA indices include Assisted Needs via the percentage of people aged less than 70 years of age that have a long–

term health condition or disability and need assistance with core activities. Nonetheless the regression analysis will thoroughly test the value of including the Assisted Needs variable.

Multicollinearity is also likely to be an issue between ARIA+ and ATSI having a correlation with each other of 0.828. It's likely that a regression model should consider only one of these variables and not both. The bi-variate relationships and R-squared results of the correlations produced in Figures 38 and 39 outlines that the ATSI variable has 50% more explanatory value of the dependent variable than the ARIA+. Given this and the study's resource limitation of not being able to purchase the ARIA+ variable at a much higher degree of precision to two decimal places as opposed to the freely available downloadable whole number measure used in the study, ATSI will be used in developing the regression model.

Based on the assessment of the Pearson Bi-Variate Correlation Coefficients, parsimony of variables and data availability, variables that are potentially useful as explanatory variables in the regression are each of the four SEIFA variables, ATSI, Assisted Needs and out-of-pocket costs. These are summarised in Table 23. The table shows the R-squared value for each variable, determined by squaring the Pearson's correlation coefficient. This shows how much variation in DEA allocative efficiency can be attributed to each variable on its own. For example, if IRSD was used as the sole independent variable in a regression with the DEA Allocative efficiency scores, IRSD would explain 47.7% of the variation in the DEA allocative efficiency scores.

Table 23 Summary of potential independent explanatory variables to be used in the regression

Summary of Pearson Bi-Variate Correlation Coefficients with the Dependent Variable (DEA Allocative Efficiency)		
Independent Variable	**Correlation Co-efficient**	**R-squared = Correlation Co-efficient squared**
IRSD	0.691	0.477
IRSAD	0.638	0.407
IER	0.601	0.361
IEO	0.602	0.362
ATSI	-0.607	0.368
Assisted Needs	-0.412	0.170
Out of Pocket Costs	0.519	0.269

Multiple regression analysis with these variables identified as potentially useful for explaining the variation in the DEA allocative efficiency scores was then conducted. As there is known multicollinearity between the SEIFA variables multiple regression analysis will contain no more than four variables being:

1. A single SEIFA / socioeconomic variable;
2. The portion of the population that are indigenous Australians, Aboriginal and Torres Strait Islander (ATSI) peoples;
3. A variable representing the percentage of the population that has out-of-pocket costs representing at the population level financial barriers to private primary care access; and
4. The portion of the population that are living with a disability and require assistance (Assisted Needs) where the inclusion of this variable will depend to some degree upon the multicollinearity interaction of the SEIFA variable.

6.2.1 Regression Analysis Modelling Results Summary

Stepwise regression is a common automated approach to selecting independent variables for regression analysis. This functionality is built into statistical software packages and is well known amongst consultants, researchers and academics. It is a technique popular with data miners. However, it is important to state that this approach was not used for this study based on a plethora of literature that highlights significant problems with it and makes recommendations not to use it (Altman & Andersen 1989; Derksen & Keselman 1992; Smith 2018; Thompson 1989, 1995; Whittingham et al. 2006).

A good description of Stepwise regression and a summary of its pitfalls can be found in Field's (2013) 916-page comprehensive text on "Discovering Statistics Using IBM SPSS Statistics" where he donates less than 2 pages to it, deliberately does not detail the SPSS software functionality of it and dedicates this space to strongly encouraging researchers to not undertake it. Fields states that Stepwise regression selects variables based on mathematical criteria. Variable inclusion is influenced strongly on the order of variables already in the model. Key problems noted with this approach in the literature are variables excluded as bad predictors only because of variables already included in the model (under fitting the model), and potentially having too many variables in the model that are included due to their success of explaining small remaining variances (over fitting the model). This leads to unreliable R-squares that are biased and too high. The methodology also has been shown to increase the risk of making a Type II error, excluding an important predictor(s) that actually does predict the outcome. Most importantly this method detracts from the researcher being involved in critical assessment and decision making regarding variable selection (pp. 322-4).

For the HORSt, multiple regression analysis was undertaken using SPSS V24 software (IBM Corp 2016) to explore the development of regression models that best fit the data and explain the variations in DEA Allocative efficiency. In direct contrast to the automated Stepwise regression approach, twelve modelled options were developed and evaluated, three each for each of the four SEIFA indices with different combinations of the other independent variables (ATSI, Assisted Needs, out-of-pocket costs).

A summary of the modelling is presented first, outlining the combinations of variables assessed under each option. The results of the modelling are then summarised, outlining the preferred model to be used with the HORSt. Detailed individual regression analysis of the preferred model is then presented, demonstrating how the model meets all the requirements for regression. Detailed analysis of the other eleven models that were evaluated is provided in appendix 6, commencing page 297.

Table 24 outlines a summary of the included variables modelled under each option. In all models 1 through 4 each of the SEIFA indices were combined initially with the three other independent variables. In all cases these regression models with four independent variables were invalid as the Assisted Needs variable was found to be non-significant at the 5% threshold (Sig)> 0.05 when applied in conjunction with any of the SEIFA variables and ATSI and out-of-pocket costs. Assisted needs was also found to be non-significant at the 5% threshold in models 2a, 3a and 4a, when combined with IRSAD and ATSI, IER and ATSI, or IEO and ATSI. Full details of this modelling and results are found in appendix 6 (page 297).

Table 24 HORSt multiple regression models evaluated

Options Modellled	Model 1 SEFIA =IRSD			Model 2 SEFIA =IRSAD			Model 3 SEFIA =IER			Model 4 SEFIA =IEO		
	Model 1	**Model 1a**	**Model 1b**	**Model 2**	**Model 2a**	**Model 2b**	**Model 3**	**Model 3a**	**Model 3b**	**Model 4**	**Model 4a**	**Model 4b**
Independent Variables in Multiple Regression	IRSD	IRSD	IRSD	IRSAD	IRSAD	IRSAD	IER	IER	IER	IEO	IEO	IEO
	ATSI	ATSI	ATSI	ATSI	ATSI	ATSI	ATSI	ATSI	ATSI	ATSI	ATSI	ATSI
	Assisted Needs	Assisted Needs	Out of Pocket Costs	Assisted Needs	Assisted Needs	Out of Pocket Costs	Assisted Needs	Assisted Needs	Out of Pocket Costs	Assisted Needs	Assisted Needs	Out of Pocket Costs
	Out of Pocket Costs			Out of Pocket Costs			Out of Pocket Costs			Out of Pocket Costs		

A summary of the regression models that were found to be valid using three independent variables and conforming to all the necessary axioms of robust regression that were outlined in Chapter Four (page 128) is provided in Table 25. Table 25 demonstrate that models 1b and 3b are almost identical in predicting the variation in the DEA Allocative efficiency scores, explaining 63.2% and 63.3% respectively. Models 2b, 4b and 1a explain 62%, 61% and 57.2% respectively. All these multiple regression models explain the variation in DEA scores better than the individual variables as shown in Table 23 on page 208.

Table 25 HORSt multiple regression model results

	Model 1a	**Model 1b**	**Model 2b**	**Model 3b**	**Model 4b**
R-square	0.572	0.632	0.620	0.633	0.610
Adjusted R-square	0.557	0.619	0.606	0.620	0.596
Independent Variables	IRSD	IRSD	IRSAD	IER	IEO
	ATSI	ATSI	ATSI	ATSI	ATSI
	Assisted Needs	Out of Pocket Costs	Out of Pocket Costs	Out of Pocket Costs	Out of Pocket Costs

Table 25 shows a summary of the regression models found to be robust and parsimonious predictors of the DEA Allocative Efficiency scores. What is apparent from the five models is that they all have around the same level of prediction of the dependent variable, around 60%, irrespective of the SEIFA variable chosen and with one exception, Assisted Needs in model 1a, the SEIFA variable is the only variable of difference. Given that all the models meet all of the assumptions required for regression (as per demonstrated in appendix 6 and the following section), there is no reason not to select the model that has the highest coefficient of determination (R-square) for use in the HORSt being Model

3b. The next section presents the preferred model. This will be utilised for calculating the HORSt share of resources amongst NSW populations and the NSW LHNs.

6.2.2 HORSt Regression Model –analysis of Model 3b (preferred model)

Table 26 Regression Model 3b (IER + ATSI + Out-of-pocket Costs)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.796[a]	.633	.620	9.47808	1.927

a. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IER
b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13015.987	3	4338.662	48.296	.000[b]
	Residual	7546.060	84	89.834		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score
b. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IER

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-17.088	21.294		-.802	.425		
	IER	.078	.022	.281	3.617	.001	.722	1.385
	ATSI_prop	-153.117	25.857	-.439	-5.922	.000	.796	1.257
	OO_pocket_costs_ALL	45.358	.083	.381	5.453	.000	.895	1.117

a. Dependent Variable: DEA_Allocative_Efficiency_Score

Table 26 shows that IER, ATSI and Out-of-pocket Costs, in a regression model together are all significant linear predictors of the DEA Allocative Efficiency Score. This model meets all the requirements of robust regression outlined in appendix 7, commencing on page 318. The regression model is significant as per the F statistic in the ANOVA section. There is no indication of multicollinearity as per the VIFs. This model explains 63.3% of the variation in the DEA Allocative Efficiency scores, 62% adjusted for the number of independent variables included. Proof of this model (3b) meeting all the other regression assumptions for robust regression is now presented.

The Durbin Watson statistic (d) 1.927 in Table 26 is demonstrating the model exhibits no auto-serial correlations. As per the appendix 7 section A7.5 (page 323) as d 1.927>1.6990 (the critical value from the Durbin Watson table), the H_0 is not rejected and the residuals are independent. In addition, Figure 42 shows a line graph of regression unstandardized residuals. Between case numbers there is no discernible pattern of association so independence for the errors can be confirmed and therefore there is no autocorrelation or serial correlation observed.

Figure 42 Line Graph of Regression Residuals -Model 3b (IER + ATSI + Out-of-pocket Costs)

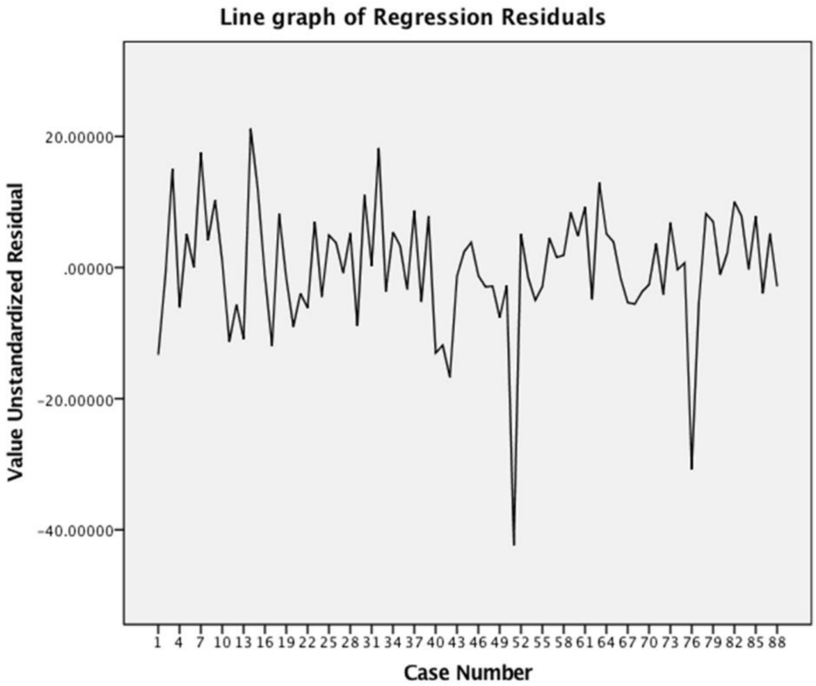


Figure 43 is a scatter plot that tests for heteroscedasticity. There is no discernible pattern to indicate any association with standardised predicted values on the x axis with the regression residuals on the y axis so we can conclude that the model meets the assumption of homoscedasticity as discussed in appendix 7, section 7.4 (page 322).

Figure 43 Scatter plot of regression standardised residuals versus regression – Model 3b (IER + ATSI + Out-of-pocket Costs)

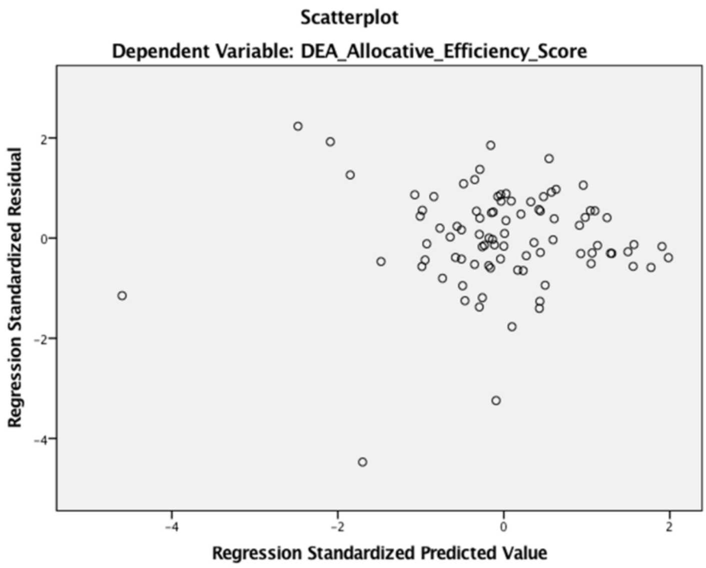


Figure 44 shows a histogram indicating pictorially that the residuals are normally distributed and Figure 45 is a graph that shows the residuals are very close to perfect normality (a straight line). It can be concluded from this that regression residuals meet the requirement of being normally distributed as discussed in appendix 7, section 7.2 (page 319).

Figure 44 Histogram of regression residuals– Model 3b (IER + ATSI + Out-of-pocket Costs)

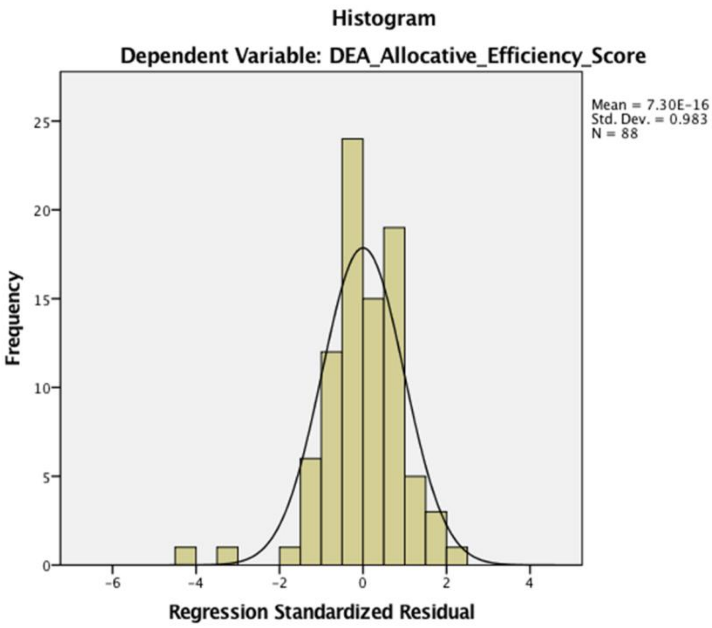
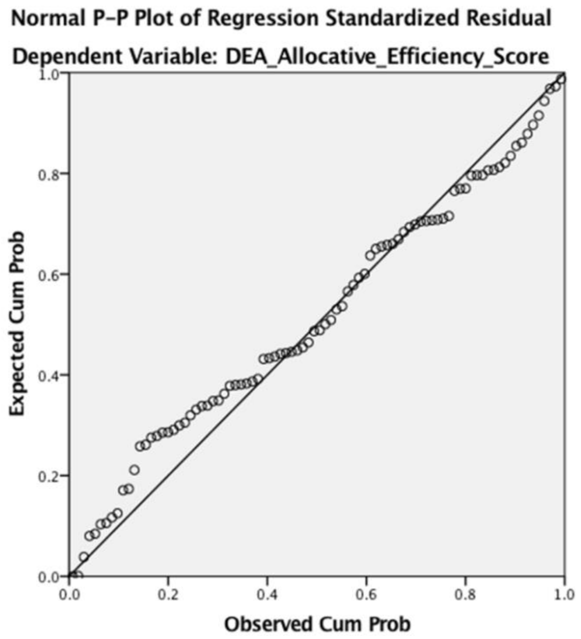


Figure 45 Normal P-P plot of regression standardised residuals– Model 3b (IER + ATSI + Out-of-pocket Costs)



It can therefore be concluded that regression Model 3b containing IER, ATSI and Out-of-pocket Costs is a robust and parsimonious option for the HORSt regression.

Model 3b is summarised in equation 21.

Equation 21

$$\hat{y} = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3$$
$$\hat{y} = -17.088 + (0.078 \times x_1) + (-153.117 \times x_2) + (45.3577 \times x_3)$$

where:

- $\hat{y}$**=** the predicted efficiency score of each **DMU (SA3)**
- b_0 = the value of the outcome when the predictors are zero, the regression constant **-17.088**;
- x_1= predictor / independent variable **IER**;
- b_1 = the regression coefficient for **IER 0.078**;
- x_2= predictor / independent variable the percentage of the population that is ATSI;
- b_2 = the regression coefficient for the percentage of the population that is ATSI -153.117;

- x_3= predictor / independent variable the percentage of the population with Out-of-pocket Costs value for each DMU; and
- b_3 = the regression coefficient for the percentage of the population with Out-of-pocket Costs 45.3577

The interpretation of the regression coefficients is as follows:

- For every additional unit of increase in a DMU's IER, (with no change in the percentage of the population that is ATSI or the percentage of the population that has non-admitted out-of-pocket costs), the predicted DEA Allocative Efficiency Score is expected to increase by 0.078%;
- For every additional unit of increase in a DMU's percentage of the population that is ATSI, (with no change in the IER and no change in the percentage of the population that has non-admitted out-of-pocket costs) the predicted DEA Allocative Efficiency Score is expected to decrease by 1.53%; and
- For every additional unit of increase in a DMU's percentage of the population that paid Out-of-pocket Costs (with no change in the IER and no change and no change in the percentage of the population that is ATSI), the predicted DEA Allocative Efficiency Score is expected to decrease by 0.46%.

The predicted allocative efficiency scores of each DMU (SA3) calculated using equation 21 are presented in Table 27. Table 27 also provides the corresponding measured DEA Allocative Efficiency scores for comparison. A summary of the top and bottom five predicted scores and the DEA scores is provided in Table 28.

The predicted allocative efficiency scores and rankings of these scores for the DMUs are to be expected to be different from the DEA Allocative Efficiency scores. This is because both are calculated differently: the predicted scores are generated from a regression of expressed needs, the social determinants found to give rise to the allocative efficiency of desirable health status as measured by the DEA allocative efficiency scores; and the DEA allocative efficiency scores are the measured weighted ratio of desirable populations' health status output relative to populations' resourcing inputs. Furthermore, the regression modelling does not predict all the variation in the DEA scores, with the preferred model predicting 63.3%. However, because the social determinants that influence the DEA scores in the regression are demonstrated in the literature to also give rise to the health status and health outcomes at the population level used in the DEA, it is reasonable to expect that results of the regression predicted scores are somewhat indicative of the DEA measured scores and vice versa. The results in tables 27 and 28 illustrate that this is indeed the case. This result validates the HORSt methodology.

Table 27 Predicted Allocative Efficiency Scores derived from the regression equation

DMU/SA3 Code and Name	IER	% of population that is ATSI	% pop with non-admitted Out of pocket costs	Predicted Allocative Efficiency Scores	DEA Allocative Efficiency Scores
10101 Goulburn – Yass	1007	3.02%	58.4%	83.52	70.21
10102 Queanbeyan	1059	3.02%	68.3%	92.09	90.70
10103 Snowy Mountains	999	2.39%	60.9%	84.95	100.00
10104 South Coast	976	4.69%	62.4%	80.32	74.26
10201 Gosford	1014	2.58%	56.0%	83.66	88.79
10202 Wyong	986	4.28%	50.0%	76.10	76.12
10301 Bathurst	995	4.81%	50.8%	76.34	93.90
10302 Lachlan Valley	968	9.21%	47.3%	65.94	70.09
10303 Lithgow - Mudgee	972	4.98%	46.5%	72.35	82.64
10304 Orange	1001	5.40%	56.2%	78.39	79.25
10401 Clarence Valley	953	6.67%	61.5%	75.12	63.83
10402 Coffs Harbour	974	4.59%	53.6%	76.31	70.66
10501 Bourke - Cobar - Coonamble	916	29.45%	27.7%	22.03	11.13
10502 Broken Hill and Far West	917	12.04%	25.9%	47.94	69.12
10503 Dubbo	976	16.15%	46.7%	55.64	67.60
10601 Lower Hunter	988	5.04%	50.7%	75.42	74.07
10602 Maitland	1010	3.82%	60.8%	83.59	71.63
10603 Port Stephens	999	4.17%	51.2%	77.82	86.04
10604 Upper Hunter	983	5.49%	52.3%	75.10	73.46
10701 Dapto - Port Kembla	977	3.20%	39.2%	72.20	63.19
10703 Kiama - Shellharbour	1016	3.05%	44.3%	77.79	73.85
10704 Wollongong	989	2.00%	52.9%	81.14	74.99
10801 Great Lakes	956	4.57%	60.0%	77.88	84.86
10802 Kempsey - Nambucca	935	11.05%	46.4%	60.17	55.74
10804 Port Macquarie	985	3.85%	50.0%	76.71	81.65
10805 Taree - Gloucester	951	6.16%	59.3%	74.75	78.52
10901 Albury	969	2.62%	61.9%	82.73	81.88
10902 Lower Murray	974	9.57%	48.3%	66.28	71.53
10903 Upper Murray exc. Albury	980	2.74%	64.1%	84.37	75.46
11001 Armidale	970	7.38%	58.6%	73.99	85.06
11002 Inverell - Tenterfield	948	7.44%	54.6%	70.38	70.59
11003 Moree - Narrabri	959	19.04%	52.9%	52.71	70.94
11004 Tamworth - Gunnedah	977	10.52%	61.6%	71.16	67.49
11101 Lake Macquarie - East	1005	3.04%	58.8%	83.47	88.86
11102 Lake Macquarie - West	1004	4.05%	51.6%	78.60	81.92
11103 Newcastle	966	3.15%	61.6%	81.59	78.25
11201 Richmond Valley - Coastal	993	3.04%	64.8%	85.29	93.99
11202 Richmond Valley - Hinterland	954	6.11%	61.6%	76.04	70.83
11203 Tweed Valley	985	4.02%	52.1%	77.38	85.25
11301 Griffith - Murrumbidgee (West)	974	6.79%	57.3%	74.68	61.64
11302 Tumut - Tumbarumba	978	4.62%	44.7%	72.55	60.71
11303 Wagga Wagga	989	5.00%	59.3%	79.48	62.71
11401 Shoalhaven	982	5.50%	56.6%	76.90	75.61
11402 Southern Highlands	1046	2.09%	61.6%	89.43	91.84

Table continues over.

Table 27 continued.

DMU/SA3 Code and Name	IER	% of population that is ATSI	% pop with non-admitted Out of pocket costs	Predicted Allocative Efficiency Scores	DEA Allocative Efficiency Scores
11501 Baulkham Hills	1128	0.34%	50.5%	93.49	97.34
11502 Dural - Wisemans Ferry	1137	0.60%	58.5%	97.45	96.23
11503 Hawkesbury	1109	2.03%	51.0%	89.62	86.68
11504 Rouse Hill - McGraths Hill	1155	1.01%	43.3%	91.29	88.47
11601 Blacktown	989	2.32%	27.7%	69.25	61.64
11602 Blacktown - North	1118	1.57%	34.8%	83.66	80.93
11603 Mount Druitt	952	5.37%	18.5%	57.47	15.08
11701 Botany	968	1.85%	40.8%	74.25	79.35
11702 Marrickville - Sydenham - Petersham	979	1.91%	47.9%	78.28	76.76
11703 Sydney Inner City	885	1.66%	53.9%	73.97	68.99
11801 Eastern Suburbs - North	1031	0.39%	68.9%	94.20	91.30
11802 Eastern Suburbs - South	984	1.73%	52.1%	80.80	85.33
11901 Bankstown	971	0.92%	32.2%	72.04	73.61
11902 Canterbury	943	0.55%	28.8%	68.85	70.73
11903 Hurstville	992	0.70%	42.4%	78.62	87.03
11904 Kogarah - Rockdale	977	0.63%	40.0%	76.46	81.25
12001 Canada Bay	1026	0.45%	51.9%	85.98	95.21
12002 Leichhardt	1042	1.19%	63.1%	91.14	86.31
12003 Strathfield - Burwood - Ashfield	966	0.68%	38.2%	74.74	87.74
12101 Chatswood - Lane Cove	1048	0.24%	60.1%	91.70	96.86
12102 Hornsby	1065	0.51%	54.8%	90.28	94.19
12103 Ku-ring-gai	1110	0.09%	67.1%	100.00	100.00
12104 North Sydney - Mosman	1026	0.22%	76.2%	100.00	91.98
12201 Manly	1077	0.34%	73.6%	99.97	94.41
12202 Pittwater	1074	0.15%	72.7%	99.63	98.83
12203 Warringah	1090	0.49%	64.4%	96.57	93.98
12301 Camden	1101	2.32%	44.7%	85.70	89.36
12302 Campbelltown (NSW)	978	3.80%	29.0%	66.67	62.53
12303 Wollondilly	1089	2.86%	41.0%	82.26	89.12
12401 Blue Mountains	1039	2.06%	54.2%	85.54	85.22
12403 Penrith	1025	2.83%	35.2%	74.68	75.39
12404 Richmond - Windsor	1012	4.38%	48.1%	77.14	46.39
12405 St Marys	989	3.74%	25.7%	66.20	60.83
12501 Auburn	931	0.72%	23.3%	65.16	73.35
12502 Carlingford	1024	0.78%	38.8%	79.37	86.38
12503 Merrylands - Guildford	946	0.96%	25.4%	66.93	65.85
12504 Parramatta	964	0.98%	32.3%	71.38	73.61
12601 Pennant Hills - Epping	1077	0.29%	51.4%	89.99	100.00
12602 Ryde - Hunters Hill	1019	0.39%	48.9%	84.13	91.96
12701 Bringelly - Green Valley	1024	0.00%	30.1%	76.61	76.34
12702 Fairfield	949	0.81%	26.7%	67.97	75.83
12703 Liverpool	994	1.55%	30.4%	72.03	68.07
12801 Cronulla - Miranda - Caringbah	1067	0.95%	57.6%	91.04	96.23
12802 Sutherland - Menai - Heathcote	1101	0.91%	58.3%	94.00	91.13

Table 28 Top and Bottom 5 Predicted Allocative Efficiency Scores and a comparison to their DEA Allocative Efficiency scores

DMU/SA3 Code and Name Top 5	Predicted Allocative Efficiency Scores	Ranking of Predicted Allocative Efficiency	DEA Allocative Efficiency Scores	Ranking DEA Allocative Efficiency Scores
12103 Ku-ring-gai	100.00	Eq 1	100	1
12104 North Sydney - Mosman	100.00	Eq 1	91.98	15
12201 Manly	99.97	3	94.41	10
12202 Pittwater	99.63	4	98.83	4
11502 Dural - Wisemans Ferry	97.45	5	96.23	7
DMU/SA3 Code and Name Bottom 5	**Predicted Allocative Efficiency Scores**	**Ranking of Predicted Allocative Efficiency**	**DEA Allocative Efficiency Scores**	**Ranking DEA Allocative Efficiency Scores**
10501 Bourke - Cobar - Coonamble	22.03	88	11.13	88
10502 Broken Hill and Far West	47.94	87	69.12	71
11003 Moree - Narrabri	52.71	86	70.94	64
10503 Dubbo	55.64	85	67.6	74
11603 Mount Druitt	57.47	84	15.08	87

The results indicate that the DMUs (SA3s) of 12103 Ku-ring-gai and 12104 North Sydney – Mosman have efficient predicted scores of 100.00. These two DMUs had DEA Allocative Efficiency scores ranked 4th and 15th. These two populations represent the benchmarked level of predicted maximised allocative efficiency subject to social determinants of the population.

The 3rd, 4th and 5th ranked predicted allocative efficiency scores were 12201 Manly (99.97), 12202 Pittwater (99.63) and 11502 Dural - Wisemans Ferry (97.45) which had DEA Allocative Efficiency scores of 94.41 (10th), 96.23 (rank 7th) and 93.98 (rank 4th) respectively. In summary, the top five ranked predicted allocative efficiency scoring DMUs featured in the top 15 for DEA Allocative Efficiency Scores.

The bottom 5 predicted allocative efficiency scores feature the two DMUs with the lowest corresponding DEA Allocative Efficiency scores: 10501 Bourke – Cobar –Coonamble and 11603 Mount Druitt. Of the bottom five Mount Druitt is the only metropolitan area, the others being rural and remote.

6.3 VERTICAL EQUITY LOADINGS AND HEALTH NEED INDICES

Using the methodology and equations outlined in section 4.5 (page 129), need indices were calculated for each SA3s using the ratio of the predicted benchmark allocative efficiency score (100) to each predicted allocative efficiency scores for each SA3. The results are shown in Table 29.

Table 29 HORSt need indices for each SA3 population in NSW

DMUs / SA3s Code and Name	SA3 HORSt Need index	DMUs / SA3s Code and Name	SA3 HORSt Need index
10101 Goulburn – Yass	119.74	11501 Baulkham Hills	106.97
10102 Queanbeyan	108.59	11502 Dural - Wisemans Ferry	102.61
10103 Snowy Mountains	117.71	11503 Hawkesbury	111.59
10104 South Coast	124.50	11504 Rouse Hill - McGraths Hill	109.54
10201 Gosford	119.53	11601 Blacktown	144.41
10202 Wyong	131.40	11602 Blacktown - North	119.53
10301 Bathurst	130.99	11603 Mount Druitt	174.02
10302 Lachlan Valley	151.64	11701 Botany	134.68
10303 Lithgow - Mudgee	138.22	11702 Marrickville - Sydenham - Petersham	127.74
10304 Orange	127.57	11703 Sydney Inner City	135.19
10401 Clarence Valley	133.13	11801 Eastern Suburbs - North	106.16
10402 Coffs Harbour	131.04	11802 Eastern Suburbs - South	123.77
10501 Bourke - Cobar - Coonamble	454.02	11901 Bankstown	138.81
10502 Broken Hill and Far West	208.58	11902 Canterbury	145.23
10503 Dubbo	179.72	11903 Hurstville	127.19
10601 Lower Hunter	132.59	11904 Kogarah - Rockdale	130.79
10602 Maitland	119.63	12001 Canada Bay	116.30
10603 Port Stephens	128.51	12002 Leichhardt	109.72
10604 Upper Hunter	133.16	12003 Strathfield - Burwood - Ashfield	133.79
10701 Dapto - Port Kembla	138.50	12101 Chatswood - Lane Cove	109.05
10703 Kiama - Shellharbour	128.55	12102 Hornsby	110.77
10704 Wollongong	123.24	12103 Ku-ring-gai	100.00
10801 Great Lakes	128.41	12104 North Sydney - Mosman	100.00
10802 Kempsey - Nambucca	166.18	12201 Manly	100.03
10804 Port Macquarie	130.35	12202 Pittwater	100.37
10805 Taree - Gloucester	133.79	12203 Warringah	103.55
10901 Albury	120.88	12301 Camden	116.68
10902 Lower Murray	150.88	12302 Campbelltown (NSW)	149.98
10903 Upper Murray exc. Albury	118.52	12303 Wollondilly	121.57
11001 Armidale	135.15	12401 Blue Mountains	116.91
11002 Inverell - Tenterfield	142.09	12403 Penrith	133.90
11003 Moree - Narrabri	189.72	12404 Richmond - Windsor	129.63
11004 Tamworth - Gunnedah	140.52	12405 St Marys	151.05
11101 Lake Macquarie - East	119.81	12501 Auburn	153.48
11102 Lake Macquarie - West	127.23	12502 Carlingford	125.99
11103 Newcastle	122.57	12503 Merrylands - Guildford	149.41
11201 Richmond Valley - Coastal	117.25	12504 Parramatta	140.09
11202 Richmond Valley - Hinterland	131.50	12601 Pennant Hills - Epping	111.12
11203 Tweed Valley	129.22	12602 Ryde - Hunters Hill	118.87
11301 Griffith - Murrumbidgee (West)	133.91	12701 Bringelly - Green Valley	130.53
11302 Tumut - Tumbarumba	137.83	12702 Fairfield	147.12
11303 Wagga Wagga	125.82	12703 Liverpool	138.83
11401 Shoalhaven	130.04	12801 Cronulla - Miranda - Caringbah	109.85
11402 Southern Highlands	111.82	12802 Sutherland - Menai - Heathcote	106.38

The need indices represent vertical equity loadings, representing each SA3 populations' capacity to benefit given their social determinants that give rise to their ability to efficiently achieve desirable health outcomes (approximated by health status) with respect to the MBS, PBS and state health provided tax payer resource inputs across the continuum of care.

The SA3 HORSt Needs Indices were then apportioned to each LHN so as to inform each LHNs need index. A summary of the LHN HORSt need indices is provided in Table 30 below. A breakdown of the construction of these LHN need indices with the supporting calculations that were outlined in the methodology section 4.5 is provided in Table 31.

Table 30 Summary of the HORSt LHN Need Indices for all NSW LHNs

LHD	LHD HORSt Need Index
Central Coast	125.27
Far West	190.93
Hunter New England	129.97
Illawarra Shoalhaven	129.09
Mid North Coast	138.74
Murrumbidgee	126.11
Nepean Blue Mountains	130.50
Northern NSW	127.20
Northern Sydney	106.55
South Eastern Sydney	122.39
South Western Sydney	138.26
Southern NSW	117.97
Sydney	130.25
Western NSW	176.08
Western Sydney	138.51

Table 31 HORSt need indices for each NSW LHN

	Calculation	*A*	*B*	*C = A x B*	*D = C / Total of C for LHN (Total of SA3s populations in the LHN)*	*H*	*LHN HNI = the sum of (H x D) for each SA3 in the LHN*
LHN	**SA3 code and name with LHN**	**Population share of SA3 in LHN (ABS 2016 Census)**	**SA3 Population (2016 ABS Census)**	**SA3 population in LHN**	**SA3 population proportion in the LHN = Each SA3 population in the LHN / Total of SA3s populations in the LHN**	**HORSt need index of each SA3 in the LHN**	**HORSt Need Index of each SA3 x SA3 pop proportion that makes up the LHN**
Central Coast	10201 Gosford	100.00%	173,257	173,257	51.67%	119.53	61.76
	10202 Wyong	100.00%	162,052	162,052	48.33%	131.40	63.50
				335,309	100.00%	**Central Coast HORSt Need Index**	**125.27**
Far West	10502 Broken Hill and Far West	100.00%	20,598	20,598	69.42%	208.58	144.79
	10902 Lower Murray	71.24%	12,737	9,074	30.58%	150.88	46.14
				29,672	100.00%	**Far West HORSt Need Index**	**190.93**
Hunter New England	10601 Lower Hunter	100.00%	89,621	89,621	9.82%	132.59	13.02
	10602 Maitland	100.00%	76,134	76,134	8.34%	119.63	9.98
	10603 Port Stephens	100.00%	73,036	73,036	8.01%	128.51	10.29
	10604 Upper Hunter	100.00%	30,877	30,877	3.38%	133.16	4.51
	10801 Great Lakes	100.00%	31,895	31,895	3.50%	128.41	4.49
	10802 Kempsey - Nambucca	0.12%	49,005	57	0.01%	166.18	0.01
	10804 Port Macquarie	0.02%	79,929	14	0.00%	130.35	0.00
	10805 Taree - Gloucester	100.00%	54,761	54,761	6.00%	133.79	8.03
	11001 Armidale	100.00%	38,098	38,098	4.18%	135.15	5.64
	11002 Inverell - Tenterfield	100.00%	38,858	38,858	4.26%	142.09	6.05
	11003 Moree - Narrabri	100.00%	26,452	26,452	2.90%	189.72	5.50
	11004 Tamworth - Gunnedah	100.00%	82,379	82,379	9.03%	140.52	12.69
	11101 Lake Macquarie - East	100.00%	123,536	123,536	13.54%	119.81	16.22
	11102 Lake Macquarie - West	100.00%	77,075	77,075	8.45%	127.23	10.75
	11103 Newcastle	100.00%	169,571	169,571	18.59%	122.57	22.78
				912,364	100.00%	**Hunter New England HORSt Need Index**	**129.97**
Illawarra Shoalhaven	10104 South Coast	0.28%	72,073	200	0.05%	124.50	0.06
	10701 Dapto - Port Kembla	100.00%	77,934	77,934	19.22%	138.50	26.61
	10703 Kiama - Shellharbour	100.00%	92,470	92,470	22.80%	128.55	29.31
	10704 Wollongong	99.98%	133,292	133,263	32.86%	123.24	40.50
	11401 Shoalhaven	100.00%	101,617	101,617	25.06%	130.04	32.58
	11402 Southern Highlands	0.15%	49,059	72	0.02%	111.82	0.02
				405,555	100.00%	**Illawarra Shoalhaven HORSt Need Index**	**129.09**
Mid North Coast	10402 Coffs Harbour	99.48%	87,943	87,482	40.44%	131.04	52.99
	10802 Kempsey - Nambucca	99.88%	49,005	48,948	22.62%	166.18	37.60
	10804 Port Macquarie	99.98%	79,929	79,915	36.94%	130.35	48.15
				216,345	100.00%	**Mid North Coast HORSt Need Index**	**138.74**
Murrumbidgee	10101 Goulburn – Yass	26.89%	73,003	19,627	6.67%	119.74	7.99
	10302 Lachlan Valley	10.61%	56,416	5,985	2.03%	151.64	3.09
	10901 Albury	100.00%	62,504	62,504	21.25%	120.88	25.69
	10902 Lower Murray	28.76%	12,737	3,663	1.25%	150.88	1.88
	10903 Upper Murray exc. Albury	100.00%	42,542	42,542	14.46%	118.52	17.14
	11301 Griffith - Murrumbidgee (West)	100.00%	49,464	49,464	16.82%	133.91	22.52
	11302 Tumut - Tumbarumba	99.99%	14,686	14,685	4.99%	137.83	6.88
	11303 Wagga Wagga	100.00%	95,644	95,644	32.52%	125.82	40.91
				294,114	100.00%	**Murrumbidgee HORSt Need Index**	**126.11**
Nepean Blue Mountains	10301 Bathurst	0.04%	47,783	17	0.00%	130.99	0.01
	10303 Lithgow - Mudgee	45.88%	47,572	21,826	5.93%	138.22	8.20
	11502 Dural - Wisemans Ferry	0.34%	27,076	92	0.02%	102.61	0.03
	11503 Hawkesbury	100.00%	25,165	25,165	6.84%	111.59	7.64
	11504 Rouse Hill - McGraths Hill	31.65%	34,081	10,786	2.93%	109.54	3.21
	12401 Blue Mountains	100.00%	78,496	78,496	21.34%	116.91	24.95
	12403 Penrith	95.28%	143,452	136,683	37.17%	133.90	49.77
	12404 Richmond - Windsor	100.00%	37,469	37,469	10.19%	129.63	13.21
	12405 St Marys	100.00%	55,427	55,427	15.07%	151.05	22.77
	12702 Fairfield	0.94%	193,076	1,807	0.49%	147.12	0.72
				367,767	100.00%	**Nepean Blue Mountains HORSt Need Index**	**130.50**

Table continues over.

Table 31 continued.

Calculation		A	B	C = A x B	D = C / Total of C for LHN (Total of SA3s populations in the LHN)	H	LHN HNI = the sum of (H x D) for each SA3 in the LHN
LHN	**SA3 code and name with LHN**	**Population share of SA3 in LHN (ABS 2016 Census)**	**SA3 Population (2016 ABS Census)**	**SA3 population in LHN**	**SA3 population proportion in the LHN = Each SA3 population in the LHN / Total of SA3s populations in the LHN**	**HORSt need index of each SA3 in the LHN**	**HORSt Need Index of each SA3 x SA3 pop proportion that makes up the LHN**
Northern NSW	10401 Clarence Valley	100.00%	50,961	50,961	17.18%	133.13	22.87
	10402 Coffs Harbour	0.52%	87,943	461	0.16%	131.04	0.20
	11201 Richmond Valley - Coastal	100.00%	80,412	80,412	27.11%	117.25	31.79
	11202 Richmond Valley - Hinterland	100.00%	71,294	71,294	24.04%	131.50	31.61
	11203 Tweed Valley	100.00%	93,458	93,458	31.51%	129.22	40.72
				296,586	100.00%	**Northern NSW HORSt Need Index**	**127.20**
Northern Sydney	11501 Baulkham Hills	18.43%	148,761	27,413	2.99%	106.97	3.19
	11502 Dural - Wisemans Ferry	49.02%	27,076	13,273	1.45%	102.61	1.48
	12101 Chatswood - Lane Cove	100.00%	117,824	117,824	12.83%	109.05	14.00
	12102 Hornsby	100.00%	83,456	83,456	9.09%	110.77	10.07
	12103 Ku-ring-gai	100.00%	123,474	123,474	13.45%	100.00	13.45
	12104 North Sydney - Mosman	100.00%	100,152	100,152	10.91%	100.00	10.91
	12201 Manly	100.00%	44,994	44,994	4.90%	100.03	4.90
	12202 Pittwater	100.00%	63,504	63,504	6.92%	100.37	6.94
	12203 Warringah	100.00%	157,846	157,846	17.19%	103.55	17.80
	12502 Carlingford	10.45%	68,864	7,196	0.78%	125.99	0.99
	12601 Pennant Hills - Epping	84.39%	49,288	41,594	4.53%	111.12	5.03
	12602 Ryde - Hunters Hill	97.49%	140,873	137,330	14.96%	118.87	17.78
				918,056	100.00%	**Northern Sydney HORSt Need Index**	**106.55**
South Eastern Sydney	11701 Botany	100.00%	49,169	49,169	4.69%	134.68	6.32
	11702 Marrickville - Sydenham - Petersham	0.04%	57,574	22	0.00%	127.74	0.00
	11703 Sydney Inner City	94.36%	230,326	217,330	20.73%	135.19	28.03
	11801 Eastern Suburbs - North	100.00%	136,152	136,152	12.99%	106.16	13.79
	11802 Eastern Suburbs - South	100.00%	149,266	149,266	14.24%	123.77	17.63
	11903 Hurstville	93.89%	132,733	124,619	11.89%	127.19	15.12
	11904 Kogarah - Rockdale	100.00%	145,493	145,493	13.88%	130.79	18.15
	12703 Liverpool	0.57%	122,238	694	0.07%	138.83	0.09
	12801 Cronulla - Miranda - Caringbah	100.00%	114,106	114,106	10.89%	109.85	11.96
	12802 Sutherland - Menai - Heathcote	100.00%	111,321	111,321	10.62%	106.38	11.30
				1,048,173	100.00%	**South Eastern Sydney HORSt Need Index**	**122.39**
South Western Sydney	10704 Wollongong	0.02%	133,292	29	0.00%	123.24	0.00
	11402 Southern Highlands	99.85%	49,059	48,987	5.07%	111.82	5.67
	11901 Bankstown	99.09%	178,409	176,784	18.30%	138.81	25.40
	11902 Canterbury	5.84%	141,819	8,289	0.86%	145.23	1.25
	12301 Camden	100.00%	64,212	64,212	6.65%	116.68	7.76
	12302 Campbelltown (NSW)	100.00%	162,845	162,845	16.86%	149.98	25.28
	12303 Wollondilly	100.00%	42,215	42,215	4.37%	121.57	5.31
	12403 Penrith	4.72%	143,452	6,769	0.70%	133.90	0.94
	12501 Auburn	0.91%	94,077	853	0.09%	153.48	0.14
	12503 Merrylands - Guildford	22.72%	157,512	35,793	3.71%	149.41	5.54
	12701 Bringelly - Green Valley	100.00%	106,378	106,378	11.01%	130.53	14.37
	12702 Fairfield	99.06%	193,076	191,269	19.80%	147.12	29.13
	12703 Liverpool	99.43%	122,238	121,544	12.58%	138.83	17.47
				965,968	100.00%	**South Western Sydney HORSt Need Index**	**138.26**

Table continues over

Table 31 continued.

	Calculation	*A*	*B*	*C = A x B*	*D = C / Total of C for LHN (Total of SA3s populations in the LHN)*	*H*	*LHN HNI = the sum of (H x D) for each SA3 in the LHN*
LHN	**SA3 code and name with LHN**	**Population share of SA3 in LHN (ABS 2016 Census)**	**SA3 Population (2016 ABS Census)**	**SA3 population in LHN**	**SA3 population proportion in the LHN = Each SA3 population in the LHN / Total of SA3s populations in the LHN**	**HORSt need index of each SA3 in the LHN**	**HORSt Need Index of each SA3 x SA3 pop proportion that makes up the LHN**
Southern NSW	10101 Goulburn – Yass	73.11%	73,003	53,376	26.11%	119.74	31.26
	10102 Queanbeyan	100.00%	59,472	59,472	29.09%	108.59	31.59
	10103 Snowy Mountains	100.00%	19,740	19,740	9.65%	117.71	11.36
	10104 South Coast	99.72%	72,073	71,873	35.15%	124.50	43.76
	11302 Tumut - Tumbarumba	0.01%	14,686	1	0.00%	137.83	0.00
				204,462	100.00%	**Southern NSW HORSt Need Index**	**117.97**
Sydney	- Petersham	99.96%	57,574	57,552	11.02%	127.74	14.08
	11703 Sydney Inner City	5.64%	230,326	12,996	2.49%	135.19	3.37
	11901 Bankstown	0.91%	178,409	1,625	0.31%	138.81	0.43
	11902 Canterbury	94.16%	141,819	133,530	25.58%	145.23	37.15
	11903 Hurstville	6.11%	132,733	8,114	1.55%	127.19	1.98
	12001 Canada Bay	100.00%	89,595	89,595	17.16%	116.30	19.96
	12002 Leichhardt	100.00%	59,540	59,540	11.40%	109.72	12.51
	Ashfield	100.00%	159,133	159,133	30.48%	133.79	40.78
				522,084	100.00%	**Sydney HORSt Need Index**	**130.25**
Western NSW	10301 Bathurst	99.96%	47,783	47,766	17.11%	130.99	22.42
	10302 Lachlan Valley	89.39%	56,416	50,431	18.07%	151.64	27.40
	10303 Lithgow - Mudgee	54.12%	47,572	25,746	9.22%	138.22	12.75
	10304 Orange	100.00%	58,991	58,991	21.13%	127.57	26.96
	10501 Bourke - Cobar - Coonamble	100.00%	25,059	25,059	8.98%	454.02	40.76
	10503 Dubbo	100.00%	71,138	71,138	25.49%	179.72	45.80
				279,131	100.00%	**Western NSW HORSt Need Index**	**176.08**
Western Sydney	11501 Baulkham Hills	81.57%	148,761	121,348	12.86%	106.97	13.76
	11502 Dural - Wisemans Ferry	50.64%	27,076	13,711	1.45%	102.61	1.49
	11504 Rouse Hill - McGraths Hill	68.35%	34,081	23,295	2.47%	109.54	2.71
	11601 Blacktown	100.00%	139,391	139,391	14.78%	144.41	21.34
	11602 Blacktown - North	100.00%	95,745	95,745	10.15%	119.53	12.13
	11603 Mount Druitt	100.00%	115,220	115,220	12.21%	174.02	21.26
	12501 Auburn	99.09%	94,077	93,224	9.88%	153.48	15.17
	12502 Carlingford	89.55%	68,864	61,668	6.54%	125.99	8.24
	12503 Merrylands - Guildford	77.28%	157,512	121,719	12.90%	149.41	19.28
	12504 Parramatta	100.00%	146,708	146,708	15.55%	140.09	21.79
	12601 Pennant Hills - Epping	15.61%	49,288	7,694	0.82%	111.12	0.91
	12602 Ryde - Hunters Hill	2.51%	140,873	3,543	0.38%	118.87	0.45
				943,267	100.00%	**Western Sydney HORSt Need Index**	**138.51**

Table 31 demonstrates that there can be quite a lot of intra-LHN variation in the health needs expressed by the individual SA3 populations' HORSt need indices. For example, as discussed on pages 190 and 196, the SA3 11603 - Mount Druitt, experiences very high public hospital usage, very low MBS and PBS usage, has some of NSW's poorest health outcomes. Mount Druitt's population faces significant socioeconomic barriers to the achievement of good health outcomes. It has a HORSt need index of 174.02 (74% higher than the benchmark SA3 populations within Northern Sydney) and represents 12.2% of the Western Sydney LHN population. The SA3 11501 - Baulkham Hills is a similar sized population portion of this LHN (12.9%). It has far better outcomes and its population has more advantageous socioeconomic status. It has a HORSt need index just 6% higher than the benchmark. The variations at the intra–LHN level demonstrates the importance of calculating needs for smaller geographical structures below the LHN level and building these up to LHN based needs indices. States wishing to adopt the HORSt as an outcomes-based commissioning tool should endeavour to consider the variation in needs at smaller population levels. This may assist with more strategically targeted commissioning amongst LHNs and also within LHNs to address specific levels of needs. The intra-LHN variation also helps explain final needs based shares of funding at the LHN level across the state.

6.4 LOCAL HEALTH DISTRICTS SHARE OF FUNDING UNDER THE HORSt

To inform state health resource distribution to NSW LHNs, the HORSt LHN shares are applied to the LHN's population as a needs adjusted population and then this inflated needs adjusted population is normalised proportionally back to the NSW State population. The methodology for doing so was outlined in section 4.5, and a worked example was provided in table7 page 132). The results are provided in Table 32 below which show the HORSt needs adjusted share of resources.

Table 32 HORSt LHN needs adjusted share of resources

LHN	HORSt Need index	LHN population 2016 census	HORSt need adjusted population = HORSt LHN need x pop / 100	Normalised Need's adjusted pop to 2016 census = (HORSt need adjusted population / total NSW HORSt need adjusted population) x total 2016 NSW pop	HORSt Resource Allocations pop shares = Normalised need adjusted pop for each LHN / total NSW pop
Central Coast	125.27	335,309	420,025	324,075	4.19%
Far West	190.93	29,672	56,654	43,712	0.56%
Hunter New England	129.97	912,364	1,185,774	914,897	11.82%
Illawarra Shoalhaven	129.09	405,555	523,518	403,926	5.22%
Mid North Coast	138.74	216,345	300,151	231,585	2.99%
Murrumbidgee	126.11	294,114	370,895	286,168	3.70%
Nepean Blue Mountains	130.50	367,767	479,929	370,295	4.78%
Northern NSW	127.20	296,586	377,257	291,077	3.76%
Northern Sydney	106.55	918,056	978,220	754,756	9.75%
South Eastern Sydney	122.39	1,048,585	1,283,361	990,192	12.79%
South Western Sydney	138.26	965,968	1,335,562	1,030,468	13.31%
Southern NSW	117.97	204,462	241,212	186,109	2.40%
Sydney	130.25	522,084	680,033	524,687	6.78%
Western NSW	176.08	279,131	491,507	379,228	4.90%
Western Sydney	138.51	943,267	1,306,559	1,008,090	13.03%
Total		7,739,265	10,030,655	7,739,265	100.00%

Table 33 applies the same methodology used with the HORSt in Table 32 to the last published version of the NSW EHUIs Acute need index (Health Policy Analysis 2014a, 2014b; Marshall & Slater 2015) to show that if the EHUIs were used with the 2016 Census what each LHNs EHUIs based share of resources would be compared to that of the HORSt. The results are somewhat similar shares of resources and given that both the EHUIs and HORSt are primarily made up from social determinants that give rise to health needs (albeit that the health needs are assessed very differently) one would expect that the differences in shares of resources would not be too vast.

Table 33 Acute EHUIs needs-based share of resources

LHN	EHUI Acute Index	LHN population 2016 census	EHUI need adjusted population = EHUI LHN need x pop / 100	Normalised Need's adjusted pop to 2016 census = (EHUI need adjusted population / total NSW EHUI need adjusted population) x total 2016 NSW pop	EHUI State Resource Allocations pop shares = Normalised need adjusted pop for each LHN / total NSW pop	2016 HORSt needs based share of resources
Central Coast	107.69	335,309	361,104	361,814	4.68%	4.19%
Far West	129.81	30,084	39,052	39,128	0.51%	0.56%
Hunter New England	108.29	912,364	987,959	989,903	12.79%	11.82%
Illawarra Shoalhaven	102.94	405,555	417,468	418,290	5.40%	5.22%
Mid North Coast	111.09	216,345	240,333	240,806	3.11%	2.99%
Murrumbidgee	113.77	294,114	334,626	335,284	4.33%	3.70%
Nepean Blue Mountains	103.31	367,767	379,943	380,691	4.92%	4.78%
Northern NSW	106.76	296,586	316,647	317,270	4.10%	3.76%
Northern Sydney	85.19	918,056	782,101	783,639	10.13%	9.75%
South Eastern Sydney	89.90	1,048,173	942,257	944,111	12.20%	12.79%
South Western Sydney	102.29	965,977	988,051	989,995	12.79%	13.31%
Southern NSW	101.51	204,462	207,550	207,959	2.69%	2.40%
Sydney	92.64	522,084	483,634	484,586	6.26%	6.78%
Western NSW	122.51	279,131	341,967	342,640	4.43%	4.90%
Western Sydney	95.56	943,267	901,385	903,158	11.67%	13.03%
Total		7,739,274	7,724,077	7,739,274	100.00%	100.00%

EHUI Source: (Health Policy Analysis 2014a, 2014b; Marshall & Slater 2015).

6.4.1 Resource allocation funding adjustments to maximise equity of health funding across the continuum of care

The HORSt represents health needs in the context of social determinants that underpin populations' capacity to benefit. Health funding equity can be maximised when financial adjustments are made in alignment with each LHNs proportional health needs so as to provide a financial opportunity of populations to benefit. As outlined in the methodology and the core aims for this study, the HORSt identifies the quantum of funding adjustments from the current pool of resources across the continuum of care that is required to maximise equity of health funding. Given that the state cannot control the Commonwealth contribution of spending in the private sector, represented in the study by MBS and PBS expenditure, the adjustments are a residual adjustment applied to state health funding, after the total pool of resources for populations including the MBS and PBS Commonwealth subsidisation is considered. Table 34 (page 229), as per the methodology outlined in section 4.5.1 (page 134) shows these results.

Table 34 demonstrates the results of the HORSt for 2015-16. This provides each LHN populations' 2015-16 quantum of expenditure of MBS, PBS and NSW State Public Hospitals by LHN of residence.

This is the total pool of included taxpayer resources in the study and the focus of the HORSt for maximising needs-based equity for populations' share of these resources.

The public hospital costs in the pool are the dollar value of the total NWAUs for the clinical streams of Acute, Emergency Department, Sub Acute and Non-Acute Services, Acute Mental Health and Non-admitted services by LHN of residence for that year multiplied by the state price. In 2015-16 according to the NSW Health Activity Based Management (ABM) portal there was 2,467,947 NWAUs across these streams (NSW ABF Taskforce 2019). The 2015-16 NSW state price per NWAU was $4,569 (ABF Taskforce 2016, p. 22).

The total pool of resources included in this study for 2015-16 MBS, PBS and State Public Hospital costs is $22.2 billion. Each LHN populations share of this resource pool is calculated and then compared to the HORSt's health needs share of these resources. The difference between the shares represents the quantum of vertical equity adjustments, a residual adjustment that the state can make to align the HORSt so health funding equity can be maximised with respect to the total pool of resources and the underlying population health needs. Note that that column C in Table 34, the state health system resourcing, reconciles with Table 3 on page 28.

Table 34 Quantum of funding adjustments and shares of funding required for maximising health funding equity

LHN	2015-16 Resource Pool					HORSt share and Quantum of adjustments		
	A	B	C	$D = A + B + C$	$E = \frac{LHN's\ share\ (D)}{\Sigma\ D}$	H	$HS = H\ x\ \Sigma D$	$R = HS - D$
	2015-16 MBS $Mil	2015-16 PBS $Mil	2015-16 NSW State Health System payments Total Cost all inpatient & outpatient activity $Mil	2015-16 Total Resources (MBS + PBS + State Health Public Hospitals) "Resource Pool" $Mil	2015-16 Share of Total Resources (MBS + PBS + State Health Public Hospitals) "Resource Pool" %	HORSt share of resources based on health needs %	HORSt share of 2015-16 "Resource Pool" $Mil	HORSt Vertical Equity Adjustment $ (+ or -) from resource pool shares $Mil
Central Coast	$360	$187	$737	$1,284	5.48%	4.19%	$981	-$303
Far West	$29	$17	$79	$125	0.53%	0.56%	$132	$8
Hunter New England	$856	$470	$1,713	$3,040	12.98%	11.82%	$2,768	-$271
Illawarra Shoalhaven	$425	$210	$836	$1,471	6.28%	5.22%	$1,222	-$249
Mid North Coast	$239	$138	$519	$897	3.83%	2.99%	$701	-$196
Murrumbidgee	$264	$144	$415	$824	3.52%	3.70%	$866	$42
Nepean Blue Mountains	$349	$150	$600	$1,099	4.69%	4.78%	$1,120	$21
Northern NSW	$311	$175	$570	$1,056	4.51%	3.76%	$881	-$175
Northern Sydney	$878	$332	$1,076	$2,286	9.76%	9.75%	$2,284	-$3
South Eastern Sydney	$960	$458	$1,252	$2,670	11.40%	12.79%	$2,996	$326
South Western Sydney	$936	$437	$1,540	$2,913	12.44%	13.31%	$3,118	$205
Southern NSW	$160	$108	$331	$599	2.56%	2.40%	$563	-$36
Sydney	$479	$217	$894	$1,590	6.79%	6.78%	$1,588	-$3
Western NSW	$248	$136	$564	$947	4.05%	4.90%	$1,147	$200
Western Sydney	$894	$346	$1,376	$2,616	11.17%	13.03%	$3,050	$434
Total	$7,389	$3,524	$12,503	$23,417	100.00%	100.00%	$23,417	$0

Sources: MBS and PBS purchased data (Department of Human Services 2017); NWAUS – NSW ABM Portal Quick Report by LHN of Residence (NSW ABF Taskforce 2019).

6.5 CHAPTER SUMMARY

This chapter has presented and discussed the results for the HORSt. A summary of the results are as follows.

The HORSt DEA produces meaningful results for each region's measured allocative efficiency of health outcomes relative to the use of MBS, PBS and state health resources. The findings from the regression stage successfully predict the measured allocative efficiency of the DEA, indicating that the most advantageous and disadvantageous social determinants give rise to the best and worst levels of allocative efficiency of health outcomes

The results demonstrate that populations' ability to achieve allocative efficiency in the production of desirable health status is affected by:

- Socioeconomic status, measured by the SEIFA index IER (index of economic resources);
- The proportion of the population that is indigenous;
- The proportion of the population that has an ability to pay out-of-pocket costs.

These three attributes were found to explain in the regression 63.3% of the variation in the DEA allocative efficiency scores. These results are in complete congruence with the findings of the literature, that social determinants are the single largest barrier to achieving health outcomes.

Weighting the DEA predicted scores for each LHN population to inform the HORSt shares of resourcing finds that the proportional shares for each LHN are somewhat similar to that of the EHUI, a need index derived from acute hospital utilisation as proxy of need. The application however of the HORSt to the pool of resources spanning Commonwealth and State funding does indicate adjustments that could be made, prior to adjusting for patient flows, to improve funding equity. The next chapter concludes the thesis and discusses these findings.

CHAPTER SEVEN – CONCLUSIONS

7.0 INTRODUCTION

This concluding chapter begins by demonstrating that the study's findings achieve all the aims and research questions. Throughout the chapter, the study findings are contextualised to the literature review and conceptual framework.

Reflections of the study's aims, methods and results are then discussed. The strengths and limitations of the research are examined. The unique and significant contributions of the research are revisited. Operationalising the HORSt for resource distribution is outlined.

Commentary of the applicability of the HORSt beyond establishing needs-based shares of state health resources is then provided. Finally, recommendations for the implementation of future policies in similar settings are outlined.

7.1 SUMMARY OF FINDINGS - ADDRESSING THE STUDY'S AIMS AND RESEARCH QUESTIONS

The study's findings achieve the aims of the study and the research questions. These are now presented in three subsections for each of the aims.

7.1.1 - Satisfying aim 1 of the study

Aim 1 - Develop the HORSt as a parsimonious, measurable and consistent benchmark of desirable health outcomes for states' LHNs' populations, relative to funding inputs across the continuum of care, so as to promote allocative efficiency and equity across populations.

The HORSt results outlined in the previous chapter demonstrate that the underlying methodology for the HORSt achieves the first aim of the study completely. The HORSt benchmark is parsimonious, representing a metric of the best outcomes for the resource mix of health service inputs at a macro level for populations. The HORSt DEA results for each population in comparison to the benchmark validate the aims for the development of the instrument. Populations experiencing poorer health are found to have low levels of allocative efficiency relative to the benchmark. These results are predicted by social determinants that inhibit better health outcomes. The reverse is also evident in the results for populations that have the best population health status, having far fewer social barriers to the achievement of health outcomes and therefore being able to achieve greater allocative efficiency from the mix of health services resource they consume.

Research question 1:

What measures / data of health status can best represent an acceptable level of desirable health outcomes for populations that can inform a benchmark?

The population health status data used to approximate health outcomes in the benchmark, the age-standardised rates of PPHs is a good proxy for the heath per se for the populations. The use of PPHs was justified in the literature review, whereby PPHs reflect poorer health, are statistics that are collected routinely by all state health authorities in Australia, reflect three of four of the Bradshaw axioms of social need. Furthermore, addressing these metrics of poor health outcomes are national health priorities.

The decision to include PPHs as the outcome variable in the DEA benchmark is validated in the results. The DEA produces meaningful and understandable results, ***prior*** to any explanatory regression analysis of the social determinants that predict the variations in allocative efficiency amongst populations. The DEA results themselves indicate that communities that face significant social barriers to the achievement of good health outcomes, having poor levels of health status in their population, had the poorest allocative efficiencies and vice versa.

Age-standardised rates of PPHs are representative of sicker patients and ill health in the population. As such, rates of PPHs as a metric of population health status to support the benchmark represent better health status when minimised. Contrastingly the benchmark within an output orientated DEA model that seeks to maximise output relative to inputs is established around the most advantageous health status. This situation requires transformation of the PPH metric so that low rates represent the output to be maximised. The transformation supported by established methodology in the DEA literature was not practically difficult to achieve and the transformation itself is not conceptually difficult to understand within the construction of the benchmark.

Research question 2:

What health service funding inputs should be included to represent the continuum of care?

As supported by the DEA literature presented, it is not necessary to include all of the input variables that make up the production function of the outputs (outcomes in the case of the HORSt). The DEA is a relative measure of efficiency for each DMU, relative to all other DMUs and subject to the included input and output variables. However, in order for the HORSt to guide what shares of funding ought to be provided by the state subject to the resources applied across the continuum of care, a comprehensive set of measurable inputs was sought and included in the HORSt.

The health service funding inputs used within the DEA, being the MBS, PBS and state health expenditure (SCRs), representing 62% of total health expenditure in Australia and 92% of total governments tax payer funded health expenditure at the time of the study (Australian Institute of Health and Welfare 2017a, pp. 22-30) are the most suitable for inclusion in the DEA calculation of the relative allocative efficiency of the desirable low levels of PPHs. These variables constitute the bulk of the mix of resources across the continuum of care. The literature review in Chapter Two and the review of funding and governance arrangements in Chapter Three have identified these funding inputs as routinely collectable and accurate. These inputs across the continuum of care contribute to the sensible results obtained by the DEA.

The advantages of the HORSt in considering the majority of resources across the continuum of care is that it affords resource allocation decision makers the ability to position the HORSt LHN shares in the context of funding for the overall mixed private / public system. Applying the HORSt to the pool of MBS, PBS and state health resources, informs what the state needs to spend to achieve funding equity. The governance and funding of the MBS and PBS, where private medical practitioners act as gatekeepers and there is no resource distribution mechanism to promote equity, warrants these funding inputs to also be included in the pool of resources. This makes the HORSt unique compared to previous public sector resource allocation models. Doing so helps determine what the state health system share of resource ought to be so as to enable funding equity for improved health outcomes with respect to the interactions of health service resources across the continuum of care.

Out-of-pocket costs, identified in Chapter Three as a relatively newly collected metric at the population level of the 88 DMUs of the study, have been demonstrated via the literature to be more aligned to supernormal rent-seeking profits than a factor of production. As demonstrated in the regression results, this metric is best represented as an explanatory variable in the second stage of the DEA, representing an economic barrier to access, which can affect the allocative efficiency of achieving the desirable levels of population health status.

The productive role of PHI was determined in Chapter Three to be difficult to ascertain. Data regarding PHI coverage for the 88 DMUs (ABS SA3 level) is not currently available. The PHI rebate has been demonstrated in the literature examined in Chapter Three to be regressive, exacerbating inequities and inefficient. Furthermore, as an insurance contingency rather than an expended resource it remains not suitable for inclusion in the HORSt as an input for the benchmark.

Research question 3:

What methodology should be applied to derive the benchmark?

Corresponding with the study’s first aim, populations that are allocative efficient in the production of desirable health outcomes can serve as benchmark. Resource distribution can be informed by redistributing funding to populations that have poor allocative efficiency compared to the benchmark, due to poor social determinants of health that affect allocative efficiency. Doing so represents a funding enabler on the basis of capacity to benefit and is congruent to social justice theories by Rawls and Daniels, both of which are as demonstrated in the literature review in Chapter Two as palatable approaches to resource distribution by the Australian public. Both theories are also compatible with the goals of Medicare.

The use of DEA to establish the benchmark represents a unique and significant contribution to the literature surrounding population needs-based funding models and instruments. The results for the entire NSW population represent a relative measure of the allocative efficiency for each of the 88 NSW DMUs.

In the context of establishing a benchmark, the methodological literature outlined in Chapter Five demonstrates the value of the DEA’s ability to do so as the tool of choice. The two-stage DEA employed allows an empirical measure of the allocative efficiency of desirable health outcomes from the mix of key health service inputs to be calculated, whereby the weighting of inputs can be determined through optimisation of the relative outputs using linear programming techniques. The latter stage reveals for each population area the social determinants that predict the ability of populations to achieve the benchmark and inform the vertical equity adjustments for each LHN to enable resource allocation aligned to each population’s capacity to benefit.

7.1.2 Satisfying aim 2 of the study

Aim 2 - Identify and incorporate measures of local geographical population health needs that can be used in resource allocation decisions.

Research question 4:

What are appropriate measures of population need that could be applied to support the HORSt?

The literature review highlighted that the mainstay methodology for assessing population needs in population needs-based instruments was via using utilisation as a proxy for need. The utilisation approach does not require the development of a benchmark. Placing utilisation on a par with need requires a rationale and an explanation as to what predictors of utilisation can inform the potential use of the health system. Such an approach, which largely in the literature has been used as a risk capitation model, ignores the interactions of the mix of services across the continuum of care to produce favourable health outcomes.

In direct response to the gaps in the literature the HORSt sought a different approach to population health needs assessment, via explicitly considering each population's capacity to benefit from resources across the continuum to produce desirable health outcomes. The distance each population is from achieving the benchmark represents their need via their relative capacity to benefit. In the mixed private-public Australian health care sector (described in Chapter One) the ever-increasing goal of state health systems are to keep people healthy and out of hospital. The interaction of resources across the continuum of care in this regard cannot be ignored.

For the HORSt, twelve regression models explored a combination of variables that could best explain population health needs to be used in resource allocation decisions. Seven models were eliminated due to not meeting the axioms of robust regression. The results of the DEA regression (Table 25, reproduced as Table 35 below) show the 5 models that were found to meet all statistical axioms for robust regression. Population health needs in 4 out of the 5 models (models 1b, 2b, 3b and 4b) were best represented by three variables. These are:

1. A composite measure of populations' socioeconomic status;
2. The proportion of the population that is indigenous; and
3. The proportion of the population that can pay out-of-pocket costs.

Model 1a is the exception because the proportion of the population with disabilities requiring assistance “Assisted Needs” constitutes the third variable instead of out-of-pocket costs.

Table 35 HORSt multiple regression model results (from Table 25)

	Model 1a	Model 1b	Model 2b	Model 3b	Model 4b
R-square	0.572	0.632	0.620	0.633	0.610
Adjusted R-square	0.557	0.619	0.606	0.620	0.596
Independent Variables	IRSD	IRSD	IRSAD	IER	IEO
	ATSI	ATSI	ATSI	ATSI	ATSI
	Assisted Needs	Out of Pocket Costs	Out of Pocket Costs	Out of Pocket Costs	Out of Pocket Costs

The only difference between the four models spanning the same three key areas listed above was the type of composite socioeconomic indicator. The Index of Economic Resources (IER) is the composite indicator in the preferred model 3b. Given that these four models via their r-squared results all predict around 60% of the variation in needs these three measures can be relied upon to inform the construction of LHN shares and resource allocation.

Whilst there are key differences in how needs are expressed in population needs-based models using utilisation as needs and the HORSt, both are guided by the literature to explain needs via enumerating how social determinants predict need. Table 36 shows a comparison of the HORSt and EHUI models approaches to informing need indices.

Table 36 Comparative approach to health needs - HORSt methodology and preferred regression model compared to the NSW acute EHUI

	HORSt	**EHUI acute**
Need	DEA: **Output:** Transformed age-standardised and casemix adjusted rate of PPHs **Inputs:** MBS; PBS, SCR (all age-standardised)	Acute inpatient utilisation (SCR)
Regression Dependent Variable for Need	DEA Allocative efficiency score	
Independent Variables that predict need (socioeconomic determinants)	IER ATSI Out-of-pocket costs	IEO (quintiles 1 and 2) IEO (quintiles 3 and 4) ATSI ARIA SMR75 %LONE65 %COB_HIGH_UTIL
Regression calculates	Predicted DEA efficiency score for each DMU	Expected Utilisation rate – used as need index
Need indices	Ratio of: $\frac{\mathit{benchmarked\ predicted\ DEA\ Allocative\ Efficiency\ score\ for\ State}}{\mathit{predicted\ DEA\ Allocative\ Efficiency\ score\ for\ each\ DMU\ (SA3\ area)}}$ = each SA3 population's capacity to benefit	

Source EHUI: (Health Policy Analysis 2014a, p. 26)

For the EHUI the composite socioeconomic index used as an independent predictor of utilisation was the IEO. However, to fit the model the EHUI developed dummy variables of this index, using quintile scores to demarcate the index into 4 groups and then used the upper and lower halves as two independent variables. The other variables used were the ARIA scores; the ATSI population proportion; the SMR for persons under 75 years of age (SMR75); the percentage of the population over 65 years that is living alone (%LONE65); and the percentage of the population born in a country group with higher utilisation rates (%COB_HIGH_UTIL).

As discussed in the literature review in Chapter Two and again in the methodological section regarding construct validity, the use of a mortality measure (as per the EHUI) in conjunction with other independent variables that predict utilisation in a formative construct is problematic. The other issue with the EHUI regression is that having seven variables to predict need and the division of the socioeconomic composite indicator into four dummy variables to then be combined effectively back into two, could be consider as overtly complicated, whereby as documented in the literature in Chapter Four, parsimony is a key goal for any regression formula.

Of comparative interest between the two regression models approaches to health needs is the HORSt regression considered lone person households for inclusion and excluded this as a non-significant correlation with the DEA Allocative efficiency score (page 198). This is a nuanced difference to that included in the EHUI which was lone person households over 65 years.

7.1.3 Satisfying aim 3 of the study

Identify the share and quantum of taxpayer resources provided by the state to geographical populations to maximise equity of health funding across the continuum of care so as to act as an enabler to improve equity of health outcomes.

Research question 5:

What share of funding is required for each geographical population to adjust for population health needs so as to maximise equity of health funding across the continuum of care?

The share of funding required to adjust for population health needs to maximise equity of health funding across the continuum of care is guided by the regression coefficients for each of the 88 SA3 level populations in NSW. As outlined in Chapter Four, literature pertaining to other population needs-based resourced distributions formulas guides this methodology. Once the variables that explain the variation in need have been identified through the regression, the coefficients applied to the corresponding regression variables for each of the populations derives the predicted allocative efficiency scores for each population.

The ratio of the benchmarked allocative efficiency to each population's predicted score informs the population's need index; their capacity to benefit relative to the benchmark. Weighting the results for each of the SA3's population proportions in each LHN informs the LHNs need index. Applying each LHNs need index to their populations, calculates a needs adjusted population and normalising the sum total of all LHNs needs adjusted populations to the state population derives each LHNs share of funds under the HORSt.

The NSW LHNs HORSt shares of funding as portions of funding are summarised in Table 37. For comparison purposes, shares that would be derived under the NSW acute EHUI need indices, ***if*** the acute EHUI was used for resource distribution are also provided, utilising calculations from Table 33 (page 227). Importantly, the application of the EHUIs is not the same as the HORSt. To reiterate, from Chapter One (page 26), the EHUIs is a small component of a range of adjustments applied to historically determined utilisation and population growth and punitive performance adjustments to determine the quantity of activity to be funded / purchased in each LHN. The EHUI does not establish resource distribution shares.

EHUI shares shown in Table 37 are therefore only computed as a resource distribution share in this research to demonstrate a comparison to the HORSt. If applied to a traditional resource distribution formula these shares would apply only to resources from the state budget. In contrast, the HORSt informs resource distribution amongst LHNs from the state, ***after*** considering the Commonwealth government's subsidisation of each LHN's population's use of MBS and PBS services. Nonetheless the comparative shares are weighted to the population as percentages and are comparable in the context of both being weighted population needs-based shares.

To allow fair comparison both sets of shares are based upon the respective need indices for the LHNs resident populations and are not resourcing shares adjusted for flows where patients are treated in other LHNs.

Table 37 HORSt shares of taxpayer resources for health funding equity and the EHUIs needs-based shares

LHN	**2016 HORSt needs-based share of resources**	**2016 EHUIs needs-based share of resources**
Central Coast	4.19%	4.68%
Far West	0.56%	0.51%
Hunter New England	11.82%	12.79%
Illawarra Shoalhaven	5.22%	5.40%
Mid North Coast	2.99%	3.11%
Murrumbidgee	3.70%	4.33%
Nepean Blue Mountains	4.78%	4.92%
Northern NSW	3.76%	4.10%
Northern Sydney	9.75%	10.13%
South Eastern Sydney	12.79%	12.20%
South Western Sydney	13.31%	12.79%
Southern NSW	2.40%	2.69%
Sydney	6.78%	6.26%
Western NSW	4.90%	4.43%
Western Sydney	13.03%	11.67%
Total	100.00%	100.00%

NB. Table 37 is a summary from Table 33 in Chapter Six (page 227).

As flagged in the literature review, one would expect somewhat similar shares of resources on the basis that both methods, as different as they are (illustrated in Table 36), find commonality in that the needs-based shares are heavily influenced in both methodologies by how well variables representing the social determinants of health predict each models respective proxies of health need. In this regard there can be a degree of comfort in the similarity of the LHN shares produced by the HORSt. A comparison of shares is perhaps the only method of verification open to this research. As an entirely new method for establishing population needs-based resource allocation, the HORSt would suffer credibility problems if the proportional differences in shares were significantly larger.

Research question 6:

What quantum of funding is required to be adjusted by the state from the existing pool of resources used by each geographical population?

Determining the quantum of funding to be adjusted by the state for each of the LHNs requires first calculating what is the current resource share of resources are across the pool of funds from the MBS, PBS and SCRs by area of residence. The difference between this share of the total pool of funds and what the share would be if the whole pool was allocated accordingly to the LHNs HORSt share is the adjustment the state would need to make, to enable funding equity. This is illustrated in Table 34 on page 229.

At the time of the study design (2016), the quantum of funding required to be adjusted by the state from the existing pool of resources used by each geographical population was as follows. Seven of the 15 NSW LHNs receive a positive adjustment of resources being:

- Western Sydney $434 million;
- South Eastern Sydney $326 million;
- South Western Sydney $205 million;
- Western NSW $200 million;
- Murrumbidgee $42 million;
- Nepean Blue Mountains $21 million; and
- Far West NSW $8 million.

Eight of the 15 NSW LHNs receive a negative adjustment of resources being:

- Northern Sydney -$3 million;

- Sydney -$3 million;
- Southern NSW -$36 million;
- Northern NSW -$175 million;
- Mid North Coast $196 million;
- Illawarra Shoalhaven -$249 million;
- Hunter New England -$271 million; and
- Central Coast -$303 million.

Importantly, these shares of funding are for the needs of the populations within each LHN of residence. The operationalisation of the HORSt (outside the scope of this research) will require adjustments for patient flows, between LHNs. These adjustments do not include these flows. This is discussed in section 7.2.

The vertical equity adjustments in terms of quantum of dollars are directly attributed to the HORSt assessment of individual population health needs within each LHN, and comparing this to funds already used by their populations via MBS, PBS, and state health funding allocations. Caution needs to be taken in interpreting these adjustments, positive or negative, as indicators of higher or lower needs. For example, Western Sydney and Central Coast have adjustments of a $434 million increase, and a $303 million decrease respectively. Their respective HORSt need indices are 138.51 and 125.27 (see table 31, page 222), indicative of being 38.51% and 25.27% more needy than the benchmark SA3 populations that are within the Northern Sydney LHN. However, Central Coast's current share of resources is 5.48%, whilst its HORSt share of resources, which is determined by its HORSt need index weighted for population, is 4.19% (see table 34 page 229). This means Central Coast is actually over funded relative to its needs determined by the HORSt. Contrastingly, Western Sydney is currently under funded, having a share of resources of 11.17% and HORSt needs based share of 13.03%.

The example above demonstrates that the positive and negative adjustments in dollars shown are indicative of the corrective action of the HORSt proportional shares to the current use and distribution of MBS, PBS, and state health funds respectively. The quantum of adjustments should not be taken on their own as a measure of relative needs between LHNs. The proportionality of shares shown as a percentage in column H of table 34, page 229 is indicative of more and less needy LHNs. Moreover, the HORSt need indices for LHNs and the smaller geographies of SA3s (summarised in table 31, page 222) that construct the proportional shares transparently outline areas of higher and lower relative needs.

7.2 DISCUSSION - REFLECTIONS OF THE AIMS, METHODS AND RESULTS OF THE RESEARCH

This section is a discussion that reflects upon the findings and results of the research contextualised to the conceptual framework that generated the aims and research questions that underpinned the methodology developed. Discussion comprises:

- outlining the unique and significant contributions of the research achieved;
- comparing the use and value of the HORSt methodology as an alternative population needs-based resource distribution tool to traditional models;
- recognising the study's limitations and strengths;
- operationalising the research to inform state health resource distribution to regional areas; and
- applications of the research methodology beyond the state health system.

7.2.1 The unique and significant contributions of the research achieved

The unique contributions and innovations achieved through this research are significant for a number of reasons. These are now summarised and discussed.

First, as outlined in the first three chapters, taxpayer provided and subsidised health funding in Australia is siloed across layers of government and amongst public and private sectors (Eagar et al. 2001, p. 26; Gadiel 2015; Lairson et al. 1995, p. 475). In Australia, funding is firmly aligned to the production of health outputs rather than health outcomes. Evidence for this is the widespread use of ABF for public hospitals and the nature of fee-for-service private funding. Contrastingly, the HORSt represents a significant change in focus via considering funding in the context of the appropriate mix and volume of taxpayer funded and subsidised outputs to produce an acceptable benchmarked level of health outcomes for geographical populations that seek to maximise equity across the continuum of care.

Second, in moving away from a siloed approach to funding, the HORSt advises on what the ideal level of state taxpayer funding should be as each LHNs share of state funding, relative to the total tax payer funding across the continuum of care for each LHN population, adjusted for social determinants that give rise to health outcomes. State health funding in this context is an essential residual adjustment component, after the taxpayer subsidisation from other relevant Commonwealth government funding has been considered. In other words, the HORSt represents what the state needs to spend for population funding equity, given that the state cannot control the Commonwealth contribution spending in the private sector. This aligns Medicare to its original purpose, as a *"mechanism to fund two key provider groups: hospitals and doctors"* (Duckett 2000, p. 34). The HORSt represents regional level Medicare.

Third, the HORSt does not require regulatory reform. As outlined in the third chapter, health reform in Australia that has contemplated regulatory change has faced pronounced challenges. Boxall and Gillespie (2013); Maiden (2010); Milne (2010), all document that many attempts of health funding reform have involved rancour between different levels of government and also medical professionals. The HORSt can disrupt the status quo of health funding of inputs and outputs by making the focus on health outcomes (albeit via a proxy variable of health status of the population) but it does so within the current regulatory rules of the game. It does not require constitutional change for any layer of government to abrogate or exceed their funding or governance arrangements for health.

Fourth, the HORSt, whilst considering a population needs-based approach to resource distribution, is significantly different to the former Australian state health population needs-based funding models. The former NSW and Queensland models primarily considered health service utilisation as a proxy for population health needs, with the goal being equalisation of financial access (Ho 2001; Inter-Government & Funding Strategies 2005b; Kirigia 2009), an instrument of horizontal equity. Contrastingly, the HORSt primarily considers need in terms of capacity to benefit via vertical equity. In doing so, the HORSt recognises inequity in the health system by explicitly considering the social determinants in geographical populations that give rise to the production of poor health outcomes and not through utilisation. The HORSt successfully measures the contributions of resourcing across the continuum of care whereas former models only considered resource distribution in the context of state health budget funding.

It is important to acknowledge that other population needs-based resource allocation models such as that used in the NHS in the UK (documented in Table 6 in the literature review, page 62) have used at times a health outcomes based approach, via considering factors that give rise to premature mortality so as to address inequities (Barr et al. 2014). Whilst part of the HORSt is somewhat similar to this, save for other variables that may be used to approximate geographical population health status which do not involve mortality data, the HORSt is significantly different via the inclusion of a productivity assessment of proxied health outcomes as per the two-stage DEA approach.

Fifth, unlike any previous population needs-based funding model that assumes implicit improvements in allocative efficiency, the HORSt measures the allocative efficiency of desirable health outcomes for populations, represented by age-standardised rates of PPHs and established a benchmark. The three social determinants that were found to affect populations' ability to achieve the benchmark were then used to inform resource distribution weighted population shares of funding.

Finally, the HORSt is designed to be compatible with ABF. The previous population needs-based models in NSW and QLD did operate alongside episode funding models (ABF models) (Hindle 2002; NSW Health 2005, p. 4; Schneider 2005, p. 5). As such, the equity goal of the HORSt is not in a trade-off with efficiency. The HORSt is complementary to the ongoing advancement of technical efficiency that occurs with output-based purchasing models like the ABF. The HORSt is significant in this role as it makes explicit and transparent for state governments and their local geographical populations what the fair distribution of resources ought to be to advance health outcomes and maximise equity ***before*** decisions regarding how best to purchase public health outputs are made at the local level using ABF.

7.2.2 Comparing the use and value of the HORSt methodology as an alternative population needs-based resource distribution tool to traditional models

As the differences between the HORSt and EHUI shares of funding to LHNs (outlined in Table 37) are not that large, it might be argued that perhaps utilisation (the need proxy of EHUIs) could be used as the proxy of health status to inform the needs-based benchmark used in the HORSt, or perhaps that traditional models that simply use utilisation as the proxy for need should be used. This section discusses the value in applying the HORSt or alternatives to support resource distribution decision making.

As per the logic of population needs-based models discussed in the literature, higher and lower rates of utilisation for example could reflect higher and lower rates of need. Doing so however, would make the construction of the benchmark utilising the HORSt DEA approach conceptually difficult. This is because utilisation remains an important input for the DEA, measured by MBS, PBS and state health resources using the SCRs. Furthermore, it would be illogical to have a benchmark where the outcome is health system use, especially when the benchmark is seeking a measure of allocative efficiency of producing outcomes given the mix of resources and use thereof across the continuum of care.

Within a DEA approach, if utilisation was to be the output, the DEA would be a function of the technical efficiency of the production of the utilisation. Moreover, if utilisation was pursued as an outcomes measure for a benchmark, this would pose a conceptual question of what would the inputs be? In addressing that question in the Australian context of this research, state health resource distribution, the inputs to hospital and community service outputs logically could not include the MBS and PBS resources which would be outside the production of these outputs.

As outlined in the literature review and illustrated in Table 6 (page 62), several population needs-based funding formulae that have used utilisation as need, have customised their formulae to inform localised resource allocation for specific health program budget areas. Specific health needs for program budget areas have been developed, using utilisation from specific health program areas and explanatory variables that predict the utilisation delivered under specific health program. In the case of the former NSW RDF, total needs-based shares are then the sum of the individual health program shares.

If individual need indices and needs-based shares for health program areas are desired by the state health authority in the same light, using a HORSt approach would require more program specific health status or outcome measures pertaining to the outputs of the program areas. Doing so may require multiple benchmarks and separate two-stage DEAs for the outcomes of individual program areas, so as to generate program specific need indices. This would require not only considering variables to best represent the health outcomes of individual programs but would require assessment of corresponding input variables. This would pose difficulties as this approach would somewhat ignore the interactions of the other services across the continuum of care.

A further complicating factor to this limitation of not being able to calculate the HORSt at the state health program level also involves a mismatch between typical health programs used by states and the inputs supplied by the Commonwealth (MBS and PBS). Table 38 illustrates this.

Table 38 Disconnection between the MBS and PBS categorisation of data and state health program areas

MBS / PBS categories	Typical state health program areas (NSW used for example)
MBS Category 1 - Professional Attendances Category 2 - Diagnostic Procedures and Investigations Category 3 - Therapeutic Procedures Category 4 - Oral and Maxillofacial Services (by Approved Dental Practitioners) Category 5 - Diagnostic Imaging Services Category 6 - Pathology Services Category 7 - Cleft Lip and Cleft Palate Category 8 - Miscellaneous Services Category 9 - Dentist, Dental Specialist and Dental Prosthetists. Category 10 - Dental Benefits Schedule PBS General - Ordinary Concessional - Ordinary General - Safety Net Concessional - Free Safety Net (AIHW 2018b; Department of Human Services 2015, 2017).	Aboriginal Health Acute Inpatients Emergency Departments Mental Health Obstetrics Oral Health - Adult (Caries) Oral Health - Adult (Dentures) Oral Health - Child Outpatients Patient Flows Population Health Primary & Community Based Care Rehabilitation and Extended Care Sub-Acute Non-admitted patients Teaching & Research (ABF Taskforce 2016).

It is clear from this research that the construction of the HORSt whereby needs are assessed by populations ability to achieve a benchmark of allocative efficiency of the production of desirable health outcomes is a very different approach to traditional utilisation-based needs formulas. As alluded to in the literature review, context and practicality will be the ultimate arbiter as to the appropriateness and value of use of either method. Where health systems require resource distribution instruments to consider population health needs as a form of risk adjustment for informing regionalised budgets, or program budget areas, the utilisation needs-based models will continue to have merit. The implicit nature of improving funding equity and promoting allocative efficiency through a better distribution of resources via a utilisation approach still holds. However, where more specific equity objectives are required that consider the funding across the whole continuum of care, the HORSt methodology developed can be applied.

7.2.3 Study limitations and strengths

7.2.3.1 Study limitations

State health program needs indices and resource-based shares

Drawing upon the previous section, a key study limitation is that the HORSt utilising an approach that seeks to include the allocative efficiency of health system inputs across the continuum of care to produce desirable levels of health outcomes will inevitable find difficulty in calculating health need indices to inform resource allocation of specific health programs within the LHNs funding envelopes. This limitation confines the HORSt as a top-level macro barometer of health needs. The HORSt is not designed to, nor can, answer questions as to what the mix of health service delivery ought to be. These are questions that are answered through policy and clinical improvements pertaining to models of care.

Population structures determined by Medicare Australia

The study's use of SA3 level population and socioeconomic data was completely determined by Medicare Australia's data policy, whereby the SA3 population level is the lowest level of population aggregated data that can be released for the key inputs MBS and PBS. As discussed, typically population needs-based models are built up from small measurable populations that can inform an accurate and comprehensive representation of the populations of interest in the study. The NSW EHUIs and former RDF used data built up from SA2 and LGA populations respectively.

There is no way of telling what affect smaller units of population and socioeconomic data would have on the results of the HORSt. However, smaller data units should they become available will not change the methodology established for determining the HORSt need indices for these smaller populations, or the apportioning methodology of the smaller units to the LHNs need indices.

Health outcomes proxy measure

The study's use of age-standardised and casemix adjusted rates of PPHs as performance measure of health outcomes and proxy of population health status has been well justified in this research via the literature and the results generated. However, one of the limitations deliberately applied to the DEA methodology, was the use of this metric as a single output measure in the DEA. This is completely satisfactory for a proof of concept development model that was seeking a parsimonious approach. As discussed in Chapter Four, the DEA can accommodate multiple outputs as well as the multiple inputs used. Future research may find approximating health needs in the context of health outcomes at the population level could comprise multiple metrics, whereby the linear programming of the DEA can appropriately weight the output contributions towards the calculation of allocative efficiency.

7.2.3.2 Study's strengths

Congruent with the achievement of the study's unique and significant contributions already discussed, the study's key strengths are summarised below.

As demonstrated in the development of and results achieved, the HORSt represents at a top level a robust and reliable barometer of population health needs. It successfully draws upon gaps in the research to develop health needs for local populations with LHNs that enable resource allocation to be aligned with populations capacity to benefit. It successfully measures the ability of populations to achieve desirable levels of health outcomes subject to the allocative efficiency of the bulk of publicly funded and subsidised health care in Australia. In doing so it informs state governments of what they need to redistribute to enable funding equity.

The core strength of the HORSt is synonymous with the Gonski models approach to education. The HORSt is the first model of this kind to explicitly make a link between health outcomes and expenditure and does so in an environment that has been consistently dominated by the funding and organisation of the production of health outputs.

7.2.4 Operationalising the HORSt for state health resource distributions

The HORSt was developed as a proof of concept using a case study for NSW, circa 2016. However, the methodology is designed to be applied to any recurrent year of funding. The long stability of the secondary data sources collected in the census cycle means that there is no requirement of the HORSt to be recalibrated annually. The HORSt needs-based shares can be used to guide resource allocation recurrently for each year between census data updates. Like the previous RDF and EHUIs the HORSt should be updated after each ABS census is complete.

The application of LHNs shares should as per the previous RAWP in the UK and former RDF in NSW, be applied to growth funding and not the recurrent budget per se. Doing so would avoid creating too much disruption of established service delivery patterns, over the short term, however this would lead to longer term improvements in funding equity. On this point, state health systems wanting to enable greater funding equity and allocative efficiency should be prepared to consider the HORSt as a long-term perpetuating initiative. The dismantling of the NSW RDF and the resulting erosion in funding equity that can occur once the commitment to a needs-based funding tool is abandoned was demonstrated in Chapter Two, Figure 7, page 57.

The goals of the HORSt were deliberately kept as a proof of concept model and the complications of patient flows in the planning of this research was excluded to focus on the core methodology being developed. Nonetheless, the HORSt shares calculated could be initially distributed to LHNs who hold a portion of the funds for redistribution of patient flows to other LHNs that treat the patients. The payment of net flows between LHNs could be conducted entirely with a transfer of NWAUs via ABF, guided by weightings aligned to population needs informed by the HORSt. A similar mechanism could apply to the flow transfers from LHNs to speciality networks that have state-wide service functions, such as speciality tertiary services, for example, paediatric child and maternal services. A flows adjusted share of funding could be calculated via weighting each of the LHNs populations HORSt shares for where each population is treated. However, there are endless possibilities as to how patient flows could be treated. Ultimately patient flows are a policy matter for state health authorities.

This study has used NSW as a case study. In the first chapter it was suggested that, based on the literature pertaining to the strong links between social determinants of health and outcomes, the HORSt is logically going to be more applicable in states that face more dispersed and socioeconomically different populations, where inequalities and inequities are more apparent and where the supply of services are scarcer. The outcomes of the regression for NSW are specific for that state's data and are not directly translated to other states. Nonetheless the HORSt methodology can be applied to other states, where different predictors to the three identified for NSW may be revealed.

7.2.5 Applying the HORSt methodology beyond state health resource distribution to regional areas

Whilst this thesis' scope has been focused on the state health system's distribution of funding to local populations, the application of the HORSt methodology can be applied to other population needs-based determinations, such as informing fairer and more allocatively efficient shares of funding for specific purpose payments from Commonwealth to states via the Commonwealth Grants Commission. Further, the national health funding model used to administer Commonwealth and

State funding pools could be similarly influenced by a HORSt methodology so as to promote equity and allocative efficiency across the continuum of care and with respect to the influence that social determinants have upon health outcomes.

The HORSt has been ultimately developed to guide the recurrent resource distribution between states and LHNs. Capital planning is outside the scope of this research. Nonetheless capital decision making could be informed by the HORSt need indices so as to plan for resources that are established in areas of greater need.

7.3 RECOMMENDATIONS AND CONCLUSIONS

This research set out to demonstrate a different way of distributing resources compared to the business as usual approach that all states and territories have adopted since the commencement of nation-wide ABF. This process disappointingly has not seen an advancement in enabling funding for better health outcomes or alleviating inequity and has perpetuated the status quo. Whilst ABF has been successful in driving technical efficiency (a very good thing) the public health system in Australia has been left somewhat wanting for improvements in allocative and dynamic efficiency. IHPA's quote on page 2 of this thesis in this regard is timely and telling for the need for the HORSt namely:
"Whilst Activity Based Funding models have been effective in driving technical efficiency in the delivery of public hospital services, the current pricing models designed by IHPA do not necessarily provide incentives to maximise allocative and dynamic efficiency" (IHPA 2019, p. 30).

The HORSt developed and demonstrated in this research not only responds to gaps in the literature regarding the technical approaches used to approximate health needs but has also responded to the growing view that public resources should be demonstrated to being applied to the betterment of outcomes. The HORSt makes transparent in the context of health outcomes the differences between good and poor health status and then makes explicit the taxpayer inputs and the social determinants that contribute to the achievement of those outcomes. It does so without requiring legislative reform. Importantly in this later regard, it does not seek to disrupt ABF's role as a purchasing currency or driver of technical efficiency. The HORSt positioned as the first step in the funding model needs ABF just as much as ABF needs the HORSt.

Policy and Practice Recommendations

The contextualised use of the HORSt will fundamentally determine whether or not it should be pursued in place of population needs-based models based on utilisation. For example, the HORSt could simply be used as per the proof of concept model as per this thesis, to inform an overall first step in the funding model, informing population needs-based resource allocation to LHNs at a very broad level, defining the overall resource distribution envelope for LHNs funding. To promote equity and allocative efficiency this is recommended. It is a substantial improvement on business as usual which essentially is commissioning for history plus growth. The mix of services to be purchased by the LHN amongst their facilities could be left purely as a cost and casemix decision with respect to existing infrastructure, informed by cost and ABF factors and clinical innovation of models of care. Doing so would not require any further sophistication of refining the HORSt for specific health program resource allocation.

This research has contextualised the use of traditional population needs-based models that use utilisation as a proxy for need. Whilst these models by design will focus on outputs rather than health outcomes, if policy requires oversight for resource distribution congruent with risk capitation arising from need at a health program level, then these traditional approaches as extensively outlined in the literature are sound. As demonstrated in the literature such approaches remain compatible with ABF / episode funding, which will always be a logical second payment stage in the funding model.

The recommendations for the use of the HORSt are:

1. utilise the HORSt methodology to establish the top level commissioning / funding envelope for state health funding determinations to LHNs;
    a. adjusting the HORSt LHNs populations needs-based shares of funding for fixed cost factors associated with facilities and patient flows;
2. use ABF as the payment currency for purchasing of health system outputs within each LHN.

Recommendations for further research

Operationalising the HORSt could involve a mix of methods. For the reasons outlined in this thesis and benefits associated with dealing with the gaps in the literature, as recommended the HORSt should be used for top level resource allocation guidance to local areas. However, factors that determine utilisation of health programs could be calculated separately. The nexus of how such a mix would operate is beyond the scope of this research, however this would be an opportunity for further research.

Further research could seek to address the limitation outlined with using the HORSt methodology for specific health programs, whereby the HORSt DEA represents a relative measure of the productivity of inputs across the continuum care. The use of a single output in the HORSt DEA (PPHs) and the inputs selected could be refined in further research agenda. As outlined, DEA does support multiple outputs alongside multiple inputs.

There is potential for the HORSt methodology to act as top-level sounding for capital works expansion and health technology innovations. HORSt determined health needs indices could be considered for infrastructure developments so as to not make structural funding inequities. However, as patient flows are indicative of the fact that it is not practical for each LHN to supply all facilities to address population need (such as tertiary and quaternary facilities for example), further research would be required to consider how the HORSt methodology could be practically applied.

Ultimately, the use of the HORSt, particularly as identifying the residual funding component from within the continuum of care, may lead to political discourse between Commonwealth, states and private practitioners. However, the transparency afforded under the HORSt, may contribute to greater understanding by taxpayers as to the structural funding inequities that perpetuate in the constitutionally protected private layers of the Australian health care system. Specifically, IHPA, in seeking to address its quest for improving allocative efficiency, could consider developing the HORSt at a national level to guide the distribution of quantum of NWAUs from Commonwealth to states. Doing so may require further research so as to consider what appropriate NWAU targets for each state ought to be.

The recommendations for future research surrounding the HORSt are as follows:

1. Consider using the HORSt to establish the top level outcomes-based commissioning / funding envelope for state health funding determinations to LHNs (as above) and consider state health program needs-based approaches within this envelope for localised commissioning of health programs. Patient flows / cost factor adjustments and the use of ABF as the currency in the second stage of the model still applies.
2. Consider alternative outputs and inputs to consider refinements to the HORSt and developing the methodology for specific health program areas.

3. Consider how the HORSt methodology could be practically applied to capital expansions and health technology innovations.
4. IHPA could consider developing the HORSt at a national level to guide the distribution of the quantum of NWAUs from Commonwealth to states.

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APPENDICES

APPENDIX 1 SUMMARY OF POTENTIALLY PREVENTABLE HOSPITALISATIONS (PPHs) AND IDENTIFYING ATTRIBUTES

Source: (Australian Institute of Health and Welfare 2017b)

ICD-10-AM, 7th edition codes used for identifying potentially preventable hospitalisations

Category	ICD-10-AM codes	ICD-10-AM description	Additional requirements
Vaccine preventable PPHs			
Pneumonia and influenza (vaccine-preventable)	J10	Influenza due to other identified influenza virus	In any diagnosis. Exclude people under 2 months.
	J11	Influenza, virus not identified	In any diagnosis. Exclude people under 2 months.
	J13	Pneumonia due to *Streptococcus pneumoniae*	In any diagnosis. Exclude people under 2 months.
	J14	Pneumonia due to *Haemophilus influenza*	In any diagnosis. Exclude people under 2 months.
Other vaccine-preventable conditions	A08.0	Rotaviral enteritis	In any diagnosis.
	A35	Other tetanus	In any diagnosis.
	A36	Diphtheria	In any diagnosis.
	A37	Whooping cough	In any diagnosis.
	A80	Acute poliomyelitis	In any diagnosis.
	B01	Varicella [chicken pox]	In any diagnosis.
	B05	Measles	In any diagnosis.
	B06	Rubella [German measles]	In any diagnosis.
	B16.1	Acute hepatitis B with delta-agent (coinfection) without hepatic coma	In any diagnosis.
	B16.9	Acute hepatitis B without delta-agent and without hepatic coma	In any diagnosis.
	B18.0	Chronic viral hepatitis B with delta-agent	In any diagnosis.
	B18.1	Chronic viral hepatitis B without delta-agent	In any diagnosis.
	B26	Mumps	In any diagnosis.
	G00.0	Haemophilus meningitis	In any diagnosis.
Chronic PPHs			
Asthma	J45	Asthma	As principal diagnosis. Exclude children aged less than 4 years.
	J46	Status asthmaticus	As principal diagnosis. Exclude children aged less than 4 years.
Congestive cardiac failure	I50	Heart failure	As principal diagnosis. Exclude cases with the following cardiac procedure codes: Blocks 600-606, 608-650, 653-657, 660-664, 666, 669-682, 684-691, 693, 705-707, 717 and codes 33172-00[715], 33827-01[733], 34800-00[726], 35412-00[11], 38721-01[733], 90217-02[734], 90215-02[732].
	I11.0	hypertensive heart diseased with (congestive) heart failure	As principal diagnosis. Exclude cases with the following cardiac procedure codes: Blocks 600-606, 608-650, 653-657, 660-664, 666, 669-682, 684-691, 693, 705-707, 717 and codes 33172-00[715], 33827-01[733], 34800-00[726], 35412-00[11], 38721-01[733], 90217-02[734], 90215-02[732].
	J81	Pulmonary oedema	As principal diagnosis. Exclude cases with the following cardiac procedure codes: Blocks 600-606, 608-650, 653-657, 660-664, 666, 669-682, 684-691, 693, 705-707, 717 and codes 33172-00[715], 33827-01[733], 34800-00[726], 35412-00[11], 38721-01[733], 90217-02[734], 90215-02[732].
Diabetes complications	E10.0–E10.9	Type 1 diabetes mellitus	As principal diagnosis.
	E11.0–E11.9	Type 2 diabetes mellitus	As principal diagnosis.
	E13.0–E13.9	Other specified diabetes mellitus	As principal diagnosis.
	E14.0–E14.9	Unspecified diabetes mellitus	As principal diagnosis.

Appendix Table 1 continues on next page

APPENDIX 1: SUMMARY OF POTENTIALLY PREVENTABLE HOSPITALISATIONS (PPHs) AND IDENTIFYING ATTRIBUTES continued…

COPD	J20	Acute bronchitis	As principal diagnosis. Only with additional diagnoses of J41, J42, J43, J44.
	J41	Simple and mucopurulent chronic bronchitis	As principal diagnosis.
	J42	Unspecified chronic bronchitis	As principal diagnosis.
	J43	Emphysema	As principal diagnosis.
	J44	Other chronic obstructive pulmonary disease	As principal diagnosis.
Bronchiectasis	J47	Bronchiectasis	As principal diagnosis.
	J20	Acute bronchitis	As principal diagnosis. Only with additional diagnosis of J47.
Angina	I20	Angina pectoris	As principal diagnosis. Exclude cases according to the list of procedures excluded from the Congestive cardiac failure category above.
	I24.0	Coronary thrombosis not resulting in myocardial infarction	As principal diagnosis. Exclude cases according to the list of procedures excluded from the Congestive cardiac failure category above.
	I24.8	Other forms of acute ischaemic heart disease	As principal diagnosis. Exclude cases according to the list of procedures excluded from the Congestive cardiac failure category above.
	I24.9	Acute ischaemic heart disease, unspecified	As principal diagnosis. Exclude cases according to the list of procedures excluded from the Congestive cardiac failure category above.
Iron deficiency anaemia	D50.1	Sideropenic dysphagia	As principal diagnosis.
	D50.8	Other iron deficiency anaemias	As principal diagnosis.
	D50.9	Iron deficiency anaemia, unspecified	As principal diagnosis.
Hypertension	I10	Essential (primary) hypertension	As principal diagnosis. Exclude cases with procedure codes according to the list of procedures excluded from the Congestive cardiac failure category above.
	I11.9	Hypertensive heart disease without (congestive) heart failure	As principal diagnosis. Exclude cases with procedure codes according to the list of procedures excluded from the Congestive cardiac failure category above.
Nutritional deficiencies	E40	Kwashiorkor	As principal diagnosis.
	E41	Nutritional marasmus	As principal diagnosis.
	E42	Marasmic kwashiorkor	As principal diagnosis.
	E43	Unspecified severe protein-energy malnutrition	As principal diagnosis.
	E55.0	Rickets, active	As principal diagnosis.
	E64.3	Sequelae of rickets	As principal diagnosis.
Rheumatic heart diseases	I00	Rheumatic fever without mention of heart involvement	As principal diagnosis.
	I01	Rheumatic fever with heart involvement	As principal diagnosis.
	I02	Rheumatic chorea	As principal diagnosis.
	I05	Rheumatic mitral valve diseases	As principal diagnosis.
	I06	Rheumatic aortic valve diseases	As principal diagnosis.
	I07	Rheumatic tricuspid valve diseases	As principal diagnosis.
	I08	Multiple valve diseases	As principal diagnosis.
	I09	Other rheumatic heart diseases	As principal diagnosis.

Appendix Table 1 continues on next page

APPENDIX 1: SUMMARY OF POTENTIALLY PREVENTABLE HOSPITALISATIONS (PPHs) AND IDENTIFYING ATTRIBUTES continued…

Acute PPHs			
Pneumonia (not vaccine-preventable)	J15.3	Pneumonia due to streptococcus, group B	In any diagnosis. Exclude people under 2 months.
	J15.4	Pneumonia due to other streptococci	In any diagnosis. Exclude people under 2 months.
	J15.7	Pneumonia due to *Mycophasma pneumoniae*	In any diagnosis. Exclude people under 2 months.
	J16.0	Chlamydial pneumonia	In any diagnosis. Exclude people under 2 months.
Urinary tract infections, including pyelonephritis	N10	Acute tublo-interstitial nephritis	As principal diagnosis.
	N11	Chronic tublo-interstitial nephritis	As principal diagnosis.
	N12	Tubolo-interstitial nephritis, not specified as acute or chronic	As principal diagnosis.
	N13.6	Pyonephrosis	As principal diagnosis.
	N15.1	Renal and perinephric abscess	As principal diagnosis.
	N15.9	Renal tubule-interstitial disease, unspecified	As principal diagnosis.
	N28.9	Disorders of kidney and ureter, unspecified	As principal diagnosis.
	N39.0	Urinary tract infection, site not specified	As principal diagnosis.
	N39.9	Disorder or urinary system, unspecified	As principal diagnosis.
Perforated/bleeding ulcer	K25.0	Gastric ulcer, acute with haemorrhage	As principal diagnosis.
	K25.1	Gastric ulcer, acute with perforation	As principal diagnosis.
	K25.2	Gastric ulcer, acute with both haemorrhage and perforation	As principal diagnosis.
	K25.4	Gastric ulcer, chronic or unspecified with haemorrhage	As principal diagnosis.
	K25.5	Gastric ulcer, chronic or unspecified with perforation	As principal diagnosis.
	K25.6	Gastric ulcer, chronic or unspecified with both haemorrhage and perforation	As principal diagnosis.
	K26.0	Duodenal ulcer, acute with haemorrhage	As principal diagnosis.
	K26.1	Duodenal ulcer, acute with perforation	As principal diagnosis.
	K26.2	Duodenal ulcer, acute with both haemorrhage and perforation	As principal diagnosis.
	K26.4	Duodenal ulcer, chronic or unspecified with haemorrhage	As principal diagnosis.
	K26.5	Duodenal ulcer, chronic or unspecified with perforation	As principal diagnosis.
	K26.6	Duodenal ulcer, chronic or unspecified with both haemorrhage and perforation	As principal diagnosis.
	K27.0	Peptic ulcer, site unspecified, acute with haemorrhage	As principal diagnosis.
	K27.1	Peptic ulcer, site unspecified, acute with perforation	As principal diagnosis.
	K27.2	Peptic ulcer, site unspecified, acute with both haemorrhage and perforation	As principal diagnosis.
	K27.4	Peptic ulcer, site unspecified, chronic or unspecified with both haemorrhage and perforation	As principal diagnosis.
	K27.5	Peptic ulcer, site unspecified, chronic or unspecified with both haemorrhage and perforation	As principal diagnosis.
	K27.6	Peptic ulcer, site unspecified, chronic or unspecified with both haemorrhage and perforation	As principal diagnosis.
	K28.0	Gastrojejunal ulcer, acute with haemorrhage	As principal diagnosis.
	K28.1	Gastrojejunal ulcer, acute with perforation	As principal diagnosis.
	K28.2	Gastrojejunal ulcer, acute with both haemorrhage and perforation	As principal diagnosis.
	K28.4	Gastrojejunal ulcer, chronic or unspecified with haemorrhage	As principal diagnosis.
	K28.5	Gastrojejunal ulcer, chronic or unspecified with perforation	As principal diagnosis.
	K28.6	Gastrojejunal ulcer, chronic or unspecified with both haemorrhage and perforation	As principal diagnosis.

Appendix Table 1 continues on next page

APPENDIX 1: SUMMARY OF POTENTIALLY PREVENTABLE HOSPITALISATIONS (PPHs) AND IDENTIFYING ATTRIBUTES continued…

Cellulitis	L02	Cutaneous abscess, furuncle and carbuncle	As principal diagnosis. Exclude cases with any procedure except those in blocks 1820 to 2016, or if procedure is 30216-00, 30216-01, 30216-02, 30676-00, 30223-01, 30223-02, 30064-00, 90660-00, 90661-00, and this is the only listed procedure.
	L03	Cellulitis	As principal diagnosis. Exclude cases with any procedure except those in blocks 1820 to 2016, or if procedure is 30216-00, 30216-01, 30216-02, 30676-00, 30223-01, 30223-02, 30064-00, 90660-00, 90661-00, and this is the only listed procedure.
	L04	Acute Lymphadenitis	As principal diagnosis. Exclude cases with any procedure except those in blocks 1820 to 2016, or if procedure is 30216-00, 30216-01, 30216-02, 30676-00, 30223-01, 30223-02, 30064-00, 90660-00, 90661-00, and this is the only listed procedure.
	L08	Other local infections of skin and subcutaneous tissue	As principal diagnosis. Exclude cases with any procedure except those in blocks 1820 to 2016, or if procedure is 30216-00, 30216-01, 30216-02, 30676-00, 30223-01, 30223-02, 30064-00, 90660-00, 90661-00, and this is the only listed procedure.
	L88	Pyoderma gangrenosum	As principal diagnosis. Exclude cases with any procedure except those in blocks 1820 to 2016, or if procedure is 30216-00, 30216-01, 30216-02, 30676-00, 30223-01, 30223-02, 30064-00, 90660-00, 90661-00, and this is the only listed procedure.
	L98.0	Pyogenic granuloma	As principal diagnosis. Exclude cases with any procedure except those in blocks 1820 to 2016, or if procedure is 30216-00, 30216-01, 30216-02, 30676-00, 30223-01, 30223-02, 30064-00, 90660-00, 90661-00, and this is the only listed procedure.
	L98.3	Eosinphilic cellulitis [Wells]	As principal diagnosis. Exclude cases with any procedure except those in blocks 1820 to 2016, or if procedure is 30216-00, 30216-01, 30216-02, 30676-00, 30223-01, 30223-02, 30064-00, 90660-00, 90661-00, and this is the only listed procedure.
Pelvic inflammatory disease	N70	Salpingitis and oophoritis	As principal diagnosis.
	N73	Other female pelvic inflammatory diseases	As principal diagnosis.
	N74	Other female pelvic inflammatory disorders in diseases classified elsewhere	As principal diagnosis.
Ear, nose and throat infections	H66	Suppurative and unspecified otitis media	As principal diagnosis.
	J02	Acute pharyngitis	As principal diagnosis.
	J03	Acute tonsillitis	As principal diagnosis.
	J06	Acute upper respiratory infections of multiple and unspecified sites	As principal diagnosis.
	J31.2	Chronic pharyngitis	As principal diagnosis.
Dental conditions	K02	Dental caries	As principal diagnosis.
	K03	Other diseases of hard tissues of teeth	As principal diagnosis.
	K04	Diseases of pulp and periapical tissues	As principal diagnosis.
	K05	Gingivitis and periodontal diseases	As principal diagnosis.
	K06	Other disorders of gingiva and edentulous alveolar ridge	As principal diagnosis.
	K08	Other disorders of teeth and supporting structures	As principal diagnosis.
	K09.8	Other cysts of oral region, not elsewhere classified	As principal diagnosis.
	K09.9	Cyst of oral region, unspecified	As principal diagnosis.
	K12	Stomatitis and related lesions	As principal diagnosis.
	K13	Other diseases of lip and oral mucosa	As principal diagnosis.
	K14.0	Glossitis	As principal diagnosis.
Convulsions and epilepsy	G40	Epilepsy	As principal diagnosis.
	G41	Status epilepticus	As principal diagnosis.
	R56	Convulsions, not elsewhere classified	As principal diagnosis.
Eclampsia	O15	Eclampsia	As principal diagnosis.
Gangrene	R02	Gangrene, not elsewhere classified	In any diagnosis.
	I70.24	Atherosclerosis of arteries of extremities with gangrene	As principal diagnosis.
	E09.52	Impaired glucose regulation with peripheral angiopathy, with gangrene	As principal diagnosis.

APPENDIX 2 CHARLSON CO-MORBIDITIES USING ICD-10 CODES

Condition	Charlson weights (score)	ICD-10AM codes used to identify Charlson Co-morbidities in separations data where any secondary diagnosis fields indicate any of the following codes
Acute myocardial infarction	1	I21, I22, I252
Congestive heart failure	1	I50
Peripheral vascular disease	1	I71, I790, I739, R02, Z958, Z959
Cerebral vascular accident	1	I60, I61, I62, I63, I65, I66,G450, G451, G452, G458, G459, G46, I64, G454, I670, I671, I672, I674, I675, I676, I677 I678, I679, I681, I682, I688, I69
Dementia	1	F00, F01, F02, F051
Pulmonary disease	1	J40, J41, J42, J44, J43, J45, J46, J47, J67, J44, J60, J61, J62, J63, J66, J64, J65
Connective tissue disorder	1	M32, M34, M332, M053, M058, M059, M060, M063, M069, M050, M052, M051, M353
Peptic ulcer	1	K25, K26, K27, K28
Liver disease	1	K702, K703, K73, K717, K740, K742, K746, K743, K744, K745
Diabetes	1	E109, E119, E139, E149, E101, E111, E131, E141, E105, E115, E135, E145
Diabetes complications	2	E102, E112, E132, E142 E103, E113, E133, E143 E104, E114, E134, E144
Paraplegia	2	G81 G041, G820, G821, G822
Renal disease	2	N03, N052, N053, N054, N055, N056, N072, N073, N074, N01, N18, N19, N25
Cancer	2	C0, C1, C2, C3, C40, C41, C43, C45, C46, C47, C48, C49, C5, C6, C70, C71, C72, C73, C74, C75, C76, C80, C81, C82, C83, C84, C85, C883, C887, C889, C900, C901, C91, C92, C93, C940, C941, C942, C943, C9451, C947, C95, C96
Metastatic cancer	3	C77, C78, C79, C80

Severe liver disease	3	K729, K766, K767, K721
HIV	6	B20, B21, B22, B23, B24

Adapted from (Sundararajan et al. 2004, pp. 1,290).

APPENDIX 3 ETHICS APPROVAL

From: Rob Gordon [mailto:robg@uow.edu.au]

Sent: Thursday, 16 March 2017 2:17 PM

To: Kathy Eagar

Cc: John Slater; Silvia Mendolia

Subject: RE: Amended Protocol to support HREC exemption

John, Kathy, Sylvia,

My apologies for the delay in replying. John, I have read your Research Protocol and agree that the research you are undertaking can be classified as negligible risk. On this basis, I approve your application for it to be exempted from ethical review by the Human Research Ethics committee.

Kind regards

Rob

Associate Professor Rob Gordon

Deputy Director

Australian Health Services Research Institute

University of Wollongong

APPENDIX 4 MBS / PBS DATA REQUEST APPROVAL

AGREEMENT TO PROCEED

Australian Government
Department of Human Services

ABN 90 794 605 008

Client Reference No. MI6673

Please read this document carefully, prior to signing and returning it along with the report layout.
If the specifications do not match your needs, please contact Mrs G Jenkinson (02) 61330808.
The Department of Human Services (DHS) will not commence until we receive your signed agreement.

Should you wish DHS to proceed with the request, please sign the Agreement to Proceed in the box below and return this page to DHS with a signed signature.

Client Details	Contact Information	
John Slater	Phone:	02 8738 8893
District	Mobile:	0439 065 000
Street	Email	john.slater@sswahs.nsw.gov.au
Liverpool		
NSW 2170		

Invoice details:

Organisation name:	South West Sydney Local Health District
Requestor First name and surname:	John Slater
Australian Business Number (ABN):	46738965845
Australian Company Number (ACN):	
Purchase order number (if applicable):	
Postal Address:	CNR of Goulburn and Elizabeth Street Liverpool NSW 2170

Report layout

To ensure that we have interpreted your data specifications correctly, including format and presentation, and to avoid delays please check the sample layout of the report. Acceptance of this cost estimation assumes agreement to the report layout as proposed. Please contact me if you require an alternative layout, but please be aware that this could lead to changes in the cost estimation provided.

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I agree to details specified in the report layout attached and to pay the quoted amount of $5,094.97 (GST excl). This quote is valid for 30 days. From acceptance of this quote, DHS will endeavour to complete the report within 10-12 weeks.

I understand this charge is based on the costs incurred in the extraction and presentation of information from DHS or other policy department systems to create my dataset.

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APPENDIX 5 CONFIRMATION E-MAIL EXCHANGE REGARDING TRANSLATIONAL TRANSFORMATION OF DEA OUTPUTS DATA

From: Jose Manuel Cordero Ferrera <jmcordero@unex.es>
Sent: Tuesday, 12 June 2018 7:55 PM
To: John Slater
Subject: Re: Efficiency assessment of primary care providers: A conditional nonparametric approach

Dear John,

Thanks for your interest in our research. Regarding your question, you are right. We decided to use the whole hundred up from the maximum value (474,22). There is no further computation beyond that. We also thought about the possibility of using the maximum value, but in this case we would have one 0 value, which could complicate the estimation of efficiency measures.

Best regards,

Jose Cordero

De: "John Slater" <jmrs561@uowmail.edu.au>
Para: jmcordero@unex.es
Enviados: Lunes, 11 de Junio 2018 13:24:34
Asunto: Efficiency assessment of primary care providers: A conditional nonparametric approach

Dear Professor Jose

I'm a PhD (DBA) student in Australia and Health Economist. I'm researching ACSCs as an undesirable variable in DEA. I very much enjoyed your paper on the efficiency assessment of primary care providers.

I am very interested in how you transformed the undesirable ACSCs output. I note in your paper with interest that you followed the Seiford and Zhu (2002) method and you set the value of your transformation parameter at k=500. I was wondering if this was done as the maximum rate of ACSCs per 10,000 in your paper was 474.22? I was thinking that you have assigned the parameter at the next whole hundred up from this Figure. This seemed logical to me, but I was wondering if there were any further computations to setting k at 500?

Kind regards

John Slater
University of Wollongong.

APPENDIX 6 HORSt DEA REGRESSION MODELLING, ALTERNATE MODELS TO THE PREFERRED MODEL

A6.1 Regression Model 1 (IRSD + ATSI + Out-of-pocket Costs + Assisted Needs)

Regression analysis commenced with including the IRSD variable, the ATSI variable, out-of-pocket costs and the Assisted Needs variable. Several combinations were tested. The results are presented herein.

Table A6.1.1 – Preliminary Independent Variable Assessment Regression Model 1 using IRSD as the SEIFA index

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.799[a]	.639	.621	9.45979	1.998

a. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IRSD

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13134.566	4	3283.642	36.694	.000[b]
	Residual	7427.480	83	89.488		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IRSD

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-64.792	43.279		-1.497	.138		
	IRSD	.121	.039	.485	3.116	.003	.180	5.555
	ATSI_prop	-120.060	30.791	-.344	-3.899	.000	.559	1.789
	OO_pocket_costs_ALL	36.369	.093	.305	3.907	.000	.712	1.404
	AssistNeed_prop	162.815	128.706	.154	1.265	.209	.293	3.408

a. Dependent Variable: DEA_Allocative_Efficiency_Score

The coefficients panel of Table A6.1.1 shows the significance of each variable at the 5% significance level depicted by (Sig.). At the 5% significance level the Assisted Needs proportion (Sig 0.209>0.05) is not a significant linear predictor of the DEA allocative efficiency score in a model that also includes IRSD, ATSI and out-of-pocket costs.

Whilst Assisted Needs was not a significant linear predictor of the DEA allocative efficiency score in a model that contained out-of-pocket costs, further analysis was conducted where Assisted Needs were included and the out-of-pocket costs was removed. Table A6.1.2 shows the resulting regression (labelled Model 1a) finds that Assisted Needs in a regression with IRSD and ATSI and without out-of-pocket costs is a significant linear predictor of the DEA Allocative Efficiency Score. IRSD and ATSI are also significant linear predictors in this model.

Table A6.1.2 –Regression Model 1a – IRSD + ATSI + Assisted Needs

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.757[a]	.572	.557	10.23169	1.719

a. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IRSD

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11768.303	3	3922.768	37.471	.000[b]
	Residual	8793.744	84	104.687		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IRSD

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-129.824	43.210		-3.004	.004		
	IRSD	.195	.037	.782	5.338	.000	.237	4.220
	ATSI_prop	-86.537	31.984	-.248	-2.706	.008	.606	1.650
	AssistNeed_prop	305.626	133.477	.289	2.290	.025	.319	3.133

a. Dependent Variable: DEA_Allocative_Efficiency_Score

The overall regression of Model 1a is significant as shown by the F value and Sig values in the ANOVA (analysis of variance) section of the table. The coefficient of determination (R-square 0.572) for the model with these variables explains 57.2% of the variation in the DEA Allocative efficiency score, or 55.7% when adjusted for the number of independent variables. As discussed in the preceding section regarding the bi-variate correlations, the VIF statistic shows potential multicollinearity between IRSD and Assisted Needs, although the VIF statistics are below 5, which as discussed in the methodological literature can be perfectly acceptable.

Notwithstanding a potential issue of multicollinearity, the model depicted in Table A6.1.2 meets all the required regression axioms outlined in the methodology chapter. Results of testing these required assumptions are now outlined.

The Durbin Watson statistic (d) 1.719 in Table A6.1.2 is demonstrating the model exhibits no auto-serial correlations. Hypothesis testing the Durbin Watson statistic (d) tests for autocorrelation and serial correlation was conducted. i.e.

$$H_0: Residuals\ are\ independent$$
$$H_A: Residuals\ are\ not\ independent$$

Using critical values of 1.60709 and 1.69990 from the Durbin Watson tables (Savin & White 1977) with 88 observations (DMUs / SA3s) and 3 independent variables, the decision rule for hypothesis testing is:

- Reject H_0: if d<1.60709 or (4-d)< 1.60709;
- Do not reject H_0: if d>1.69990 or (4-d)> 1.69990; and
- Test inconclusive if: 1. 60709<d<1. 69990 and 1.60709<(4-d)<1.69990.

As d (1.719>1.69990), we do not reject H_0 and find the residuals are independent.

In addition to the Durbin Watson statistic Figure A6.1A shows a line graph of regression unstandardized residuals. The fact that between case numbers there is no discernible pattern of association it can be concluded that the errors are independent and no autocorrelation or serial correlation is observed.

Figure A6.1.2 is a scatter plot that test for heteroscedasticity. If the standardised errors on the y axis can be seen to be associated with standardised predicted values on the x, we can conclude that part of the error term is influencing the deterministic part of the model. This is not the case. Therefore, the model meets the assumption of homoscedasticity.

Figure A6.1A – Line Graph of Regression Residuals – Model 1a (IRSD + ATSI + Assisted Needs)

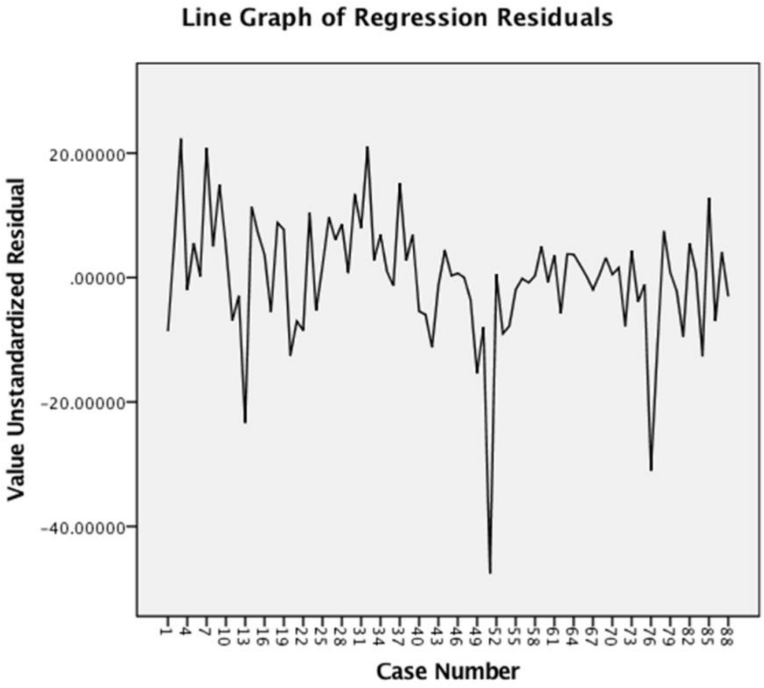


Figure A6.1B – Scatter plot of regression standardised residuals versus regression – Model 1a (IRSD + ATSI + Assisted Needs)

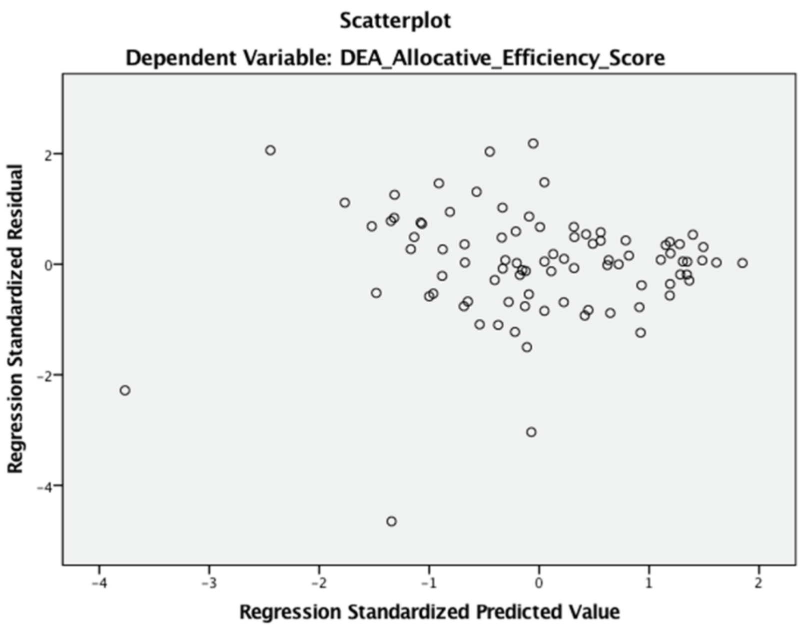


Figure A6.1.C shows a histogram indicating pictorially that the residuals are normally distributed and Figure A6.1.D is a graph that shows the residuals are very close to perfect normality (a straight line). It can be concluded from this that regression residuals meet the requirement of being normally distributed.

Figure A6.1.C– Histogram of regression residuals– Model 1a (IRSD + ATSI + Assisted Needs)

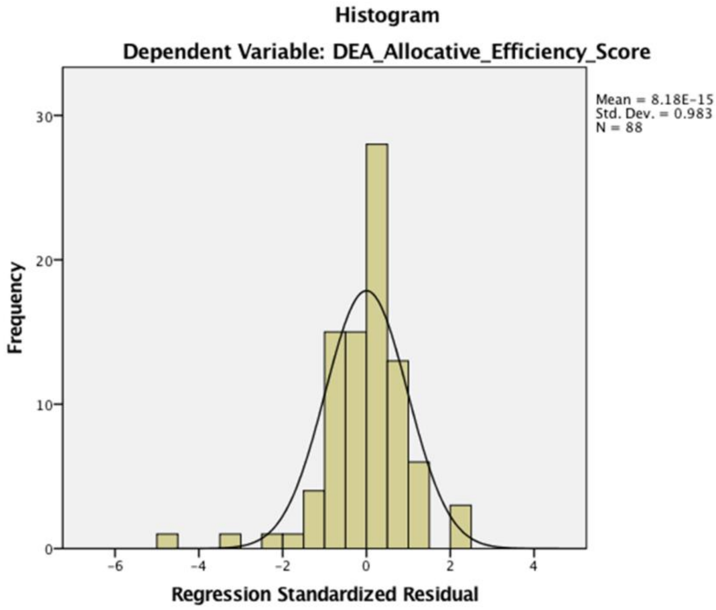
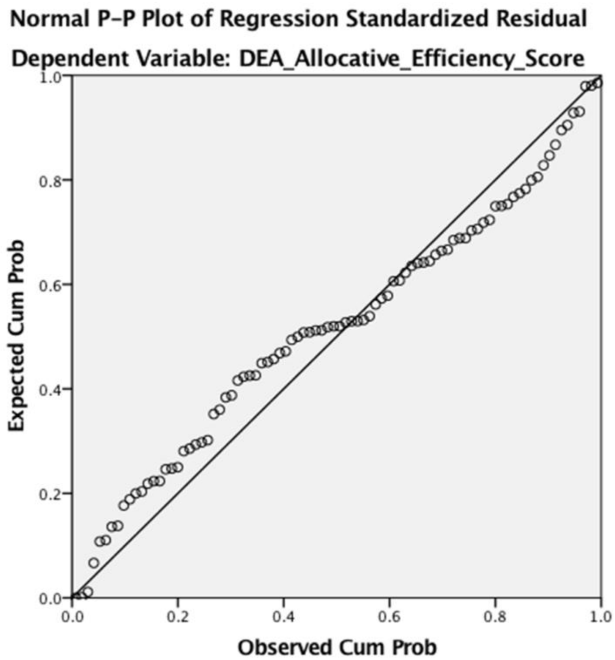


Figure A6.1.D – Normal P-P plot of regression standardised residuals– Model 1a (IRSD + ATSI + Assisted Needs)



As an alternative to Model 1a, Model 1b, adds in the out-of-pocket costs variable and removes the Assisted Needs. Table A6.1.3 shows that in regression Model 1b containing IRSD, ATSI, out-of-pocket costs, that all these variables are significant linear predictors of the DEA Allocative Efficiency Score. Furthermore, the regression model is significant as denoted by the F value and Sig values in the ANOVA (analysis of variance) part of the table. The Model Summary section of the table indicates via the coefficient of determination (the R-square 0.632) that the model with these variables explains 63.2% of the variation in the DEA Allocative efficiency scores or 61.9% when adjusted for the three independent variables.

Table A6.1.3 –Regression Model 1b (IRSD + ATSI + Out-of-pocket Costs)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.795[a]	.632	.619	9.49353	1.949

a. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IRSD

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12991.361	3	4330.454	48.048	.000[b]
	Residual	7570.685	84	90.127		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IRSD

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	-17.297	21.604		-.801	.426		
	IRSD	.081	.023	.325	3.573	.001	.531	1.883
	ATSI_prop	-134.785	28.608	-.386	-4.712	.000	.652	1.533
	OO_pocket_costs_ALL	39.713	.090	.334	4.434	.000	.775	1.291

a. Dependent Variable: DEA_Allocative_Efficiency_Score

In contrast to Model 1a, where there is a suggestion of multicollinearity via the VIF statistics, the values in model 1b are clear enough to avoid any inference. Model 1b also meets all the required regression assumptions. Proof is now presented.

The Durbin Watson statistic (d) 1.949 in Table A6.1.3 is demonstrating the model exhibits no auto-serial correlations. As per the previous section as d (1.949)>1.6990 (the critical value from the

Durbin Watson table), the H_0 is not rejected and the residuals are independent. In addition, Figure A6.1.E shows a line graph of regression unstandardized residuals. Between case numbers there is no discernible pattern of association so independence for the errors can be confirmed and therefore there is no autocorrelation or serial correlation observed.

Figure A6.1E – Line Graph of Regression Residuals - Model 1b (IRSD + ATSI + Out-of-pocket Costs)

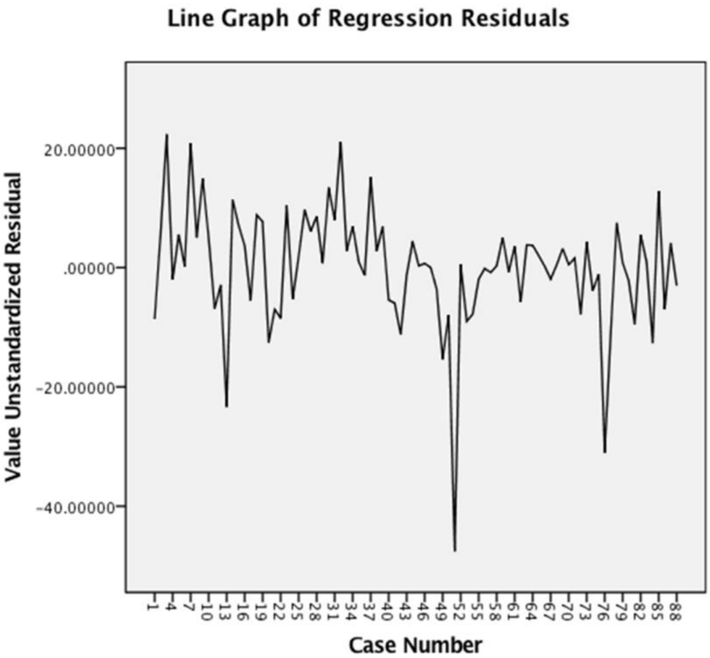


Figure A6.1F is a scatter plot that test for heteroscedasticity. If the standardised errors on the y axis can be seen to be associated with standardised predicted values on the x, we can conclude that part of the error term is influencing the deterministic part of the model. This is not the case. Therefore, the model meets the assumption of homoscedasticity.

Figure A6.1G– Scatter plot of regression standardised residuals versus regression – Model 1b (IRSD + ATSI + Out-of-pocket Costs)

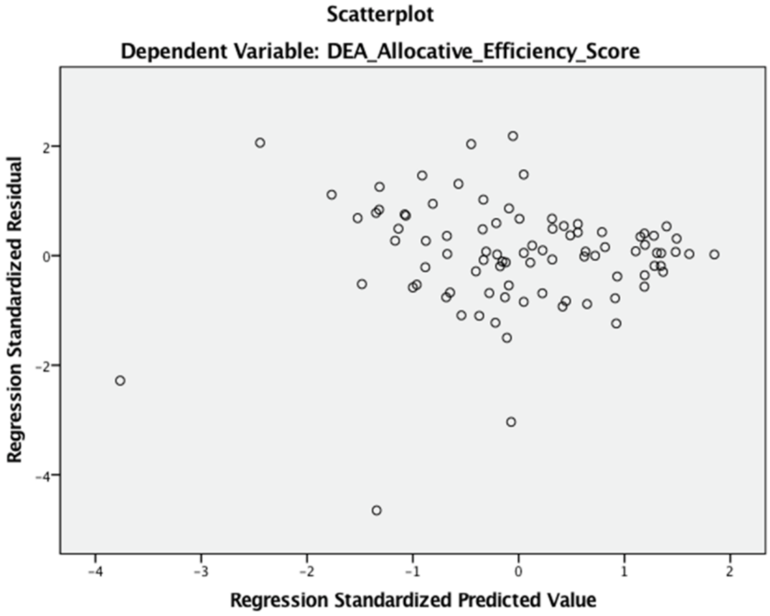


Figure A6.1H shows a histogram indicating pictorially that the residuals are normally distributed and Figure A6.1J is a graph that shows the residuals are very close to perfect normality (a straight line). It can be concluded from this that regression residuals meet the requirement of being normally distributed.

Figure A6.1H – Histogram of regression residuals– Model 1b (IRSD + ATSI + Out-of-pocket Costs)

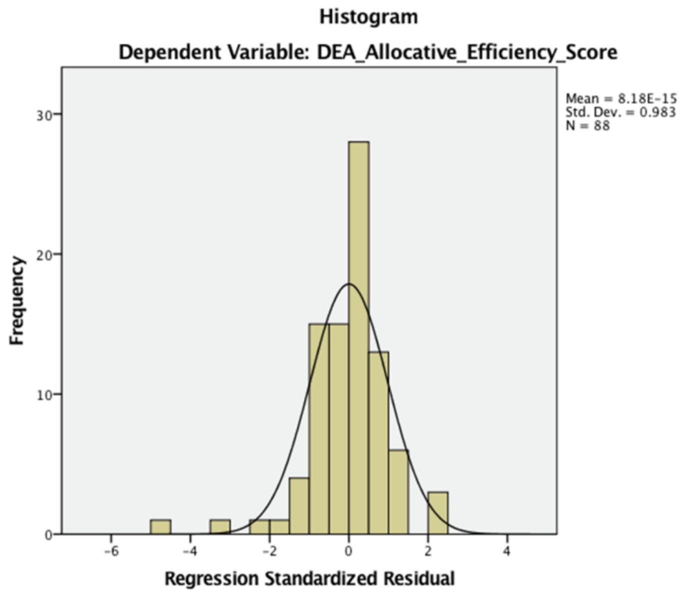
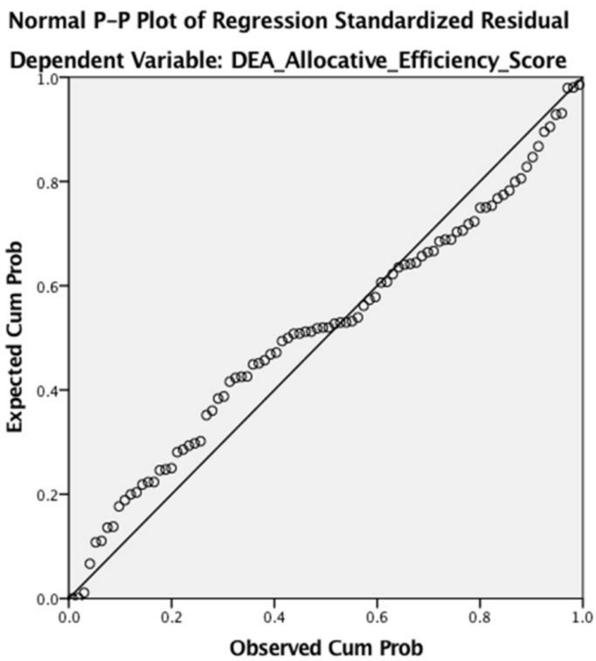


Figure A6.1J – Normal P-P plot of regression standardised residuals– Model 1b (IRSD + ATSI + Out-of-pocket Costs)



It can therefore be concluded that both models 1a and 1b are robust and parsimonious options to represent the HORSt regression. Similar analysis is now presented for other regression models that consider the other three SEIFA indices.

A6.2 Regression Model 2 IRSAD + ATSI + Out-of-pocket Costs + Assisted Needs

Preliminary regression modelling with the inclusion of the IRSAD SEIFA index included ATSI, out-of-pocket costs ALL and Assisted Needs. Doing so is a logical extension to the results of the analysis conducted to first model. Results are shown in Table A6.2.1.

Table A6.2.1 – Preliminary Independent Variable Assessment Regression Model 2 using IRSAD as the SEIFA index

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.789[a]	.623	.605	9.66081	2.025

a. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IRSAD

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12815.554	4	3203.889	34.328	.000[b]
	Residual	7746.492	83	93.331		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IRSAD

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-25.231	39.199		-.644	.522		
	IRSAD	.079	.032	.395	2.428	.017	.172	5.826
	ATSI_prop	-128.791	32.351	-.369	-3.981	.000	.528	1.893
	OO_pocket_costs_ALL	45.035	.086	.378	5.240	.000	.871	1.148
	AssistNeed_prop	124.870	141.229	.118	.884	.379	.254	3.934

a. Dependent Variable: DEA_Allocative_Efficiency_Score

Table A6.2.1 shows that there is again a potential problem of multicollinearity between the SEIFA index IRSD and Assisted Needs, VIFs being 5.826 and 3.934 respectively. Moreover, Assisted Needs (sig .379>0.05) is not a significant linear predictor of the DEA Allocative Efficiency Score in a regression also including IRSAD, ATSI and out-of-pocket costs.

Model 2a explores the removal of out-of-pocket costs to see whether or doing so would contribute to Assisted Needs being a significant predictor. Table A6.2.2 is a summary of this model and shows that this is not the case with Assisted Needs (sig .211>0.05) also being a non-significant linear predictor in regression containing IRSAD and ATSI. Also, in this model there is very little change in the VIFs for the IRSAD and Assisted Needs. Given these issues surrounding the Assisted Needs variable an alternative model is now pursued replacing Assisted Needs with out-of-pocket costs.

Table A6.2.2 –Regression Model 2a (IRSAD + ATSI + Assisted Needs)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.706[a]	.499	.481	11.07806	1.577

a. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IRSAD
b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10253.282	3	3417.761	27.849	.000[b]
	Residual	10308.764	84	122.723		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score
b. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IRSAD

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	-53.450	44.523		-1.201	.233		
	IRSAD	.124	.036	.622	3.459	.001	.185	5.413
	ATSI_prop	-104.286	36.708	-.299	-2.841	.006	.539	1.854
	AssistNeed_prop	203.169	161.038	.192	1.262	.211	.257	3.890

a. Dependent Variable: DEA_Allocative_Efficiency_Score

Table A6.2.2 is a summary of Model 2b, which consists of the IRSAD, ATSI and out-of-pocket costs variables. All of these variables when combined in a regression are significant linear predictors of the DEA Allocative Efficiency Score. This model meets all the requirements of robust regression. The regression model itself is significant as per the F statistic in the ANOVA section. There is no indication of multicollinearity as per the VIFs. This model explains 62% of the variation in the DEA Allocative Efficiency scores, 60.6% adjusted for the number of independent variables included. Proof of model 2b meeting all the other regression assumptions for robust regression is now presented.

The Durbin Watson statistic (d) 1.984 in Table A6.2.3 is demonstrating the model exhibits no auto-serial correlations. As per the previous section as d 1.984>1.6990 (the critical value from the Durbin Watson table), the H_0 is not rejected and the residuals are independent. In addition, Figure A6.2A shows a line graph of regression unstandardized residuals. Between case numbers there is no discernible pattern of association so independence for the errors can be confirmed and therefore there is no autocorrelation or serial correlation observed.

Table A6.2.3 – Regression Model 2b (IRSAD + ATSI + Out-of-pocket Costs)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.787[a]	.620	.606	9.64825	1.984

a. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IRSAD

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12742.592	3	4247.531	45.629	.000[b]
	Residual	7819.454	84	93.089		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IRSAD

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5.799	17.439		.333	.740		
	IRSAD	.055	.018	.274	3.113	.003	.585	1.710
	ATSI_prop	-141.081	29.175	-.404	-4.836	.000	.648	1.544
	OO_pocket_costs_ALL	45.839	.085	.385	5.370	.000	.881	1.135

a. Dependent Variable: DEA_Allocative_Efficiency_Score

Figure A6.2B is a scatter plot that test for heteroscedasticity. There is no discernible pattern to indicate any association with standardised predicted values on the x axis with the regression residuals on the y axis so we can conclude that the model meets the assumption of homoscedasticity.

Figure A6.2C shows a histogram indicating pictorially that the residuals are normally distributed and Figure A6.2D is a graph that shows the residuals are very close to perfect normality (a straight line). It can be concluded from this that regression residuals meet the requirement of being normally distributed.

It can therefore be concluded that regression Model 2b containing IRSAD, ATSI and out-of-pocket costs is a robust and parsimonious option for the HORSt regression.

Figure A6.2A– Line Graph of Regression Residuals -Model 2b (IRSD + ATSI + Out-of-pocket Costs)

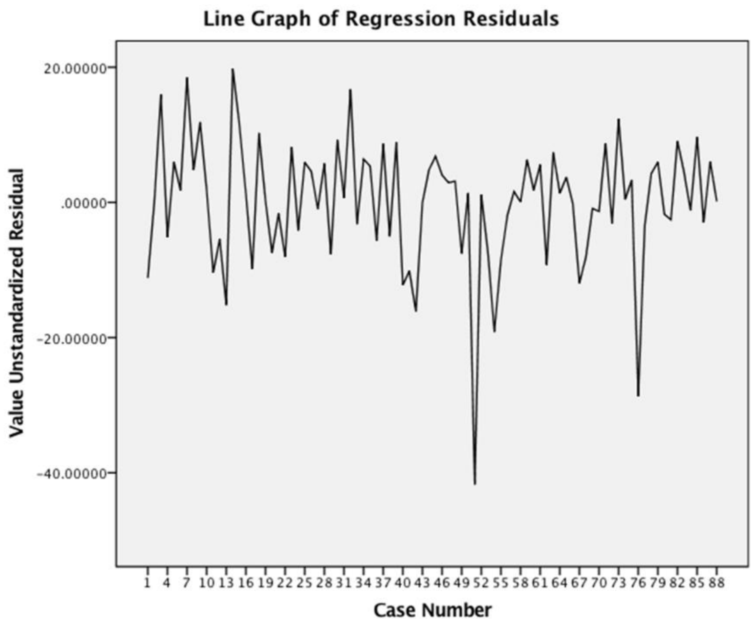


Figure A6.2B – Scatter plot of regression standardised residuals versus regression – Model 2b (IRSD + ATSI + Out-of-pocket Costs)

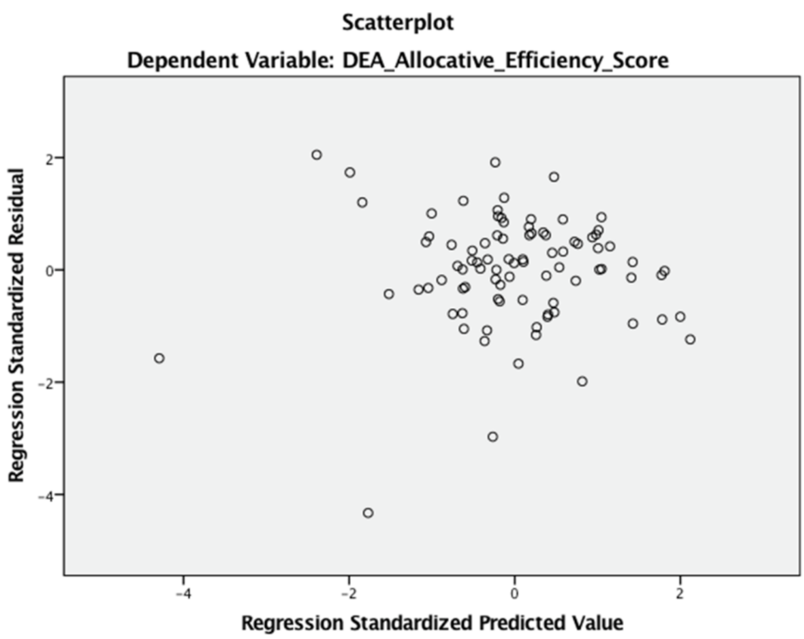


Figure A6.2C – Histogram of regression residuals– Model 2b (IRSD + ATSI + Out-of-pocket Costs)

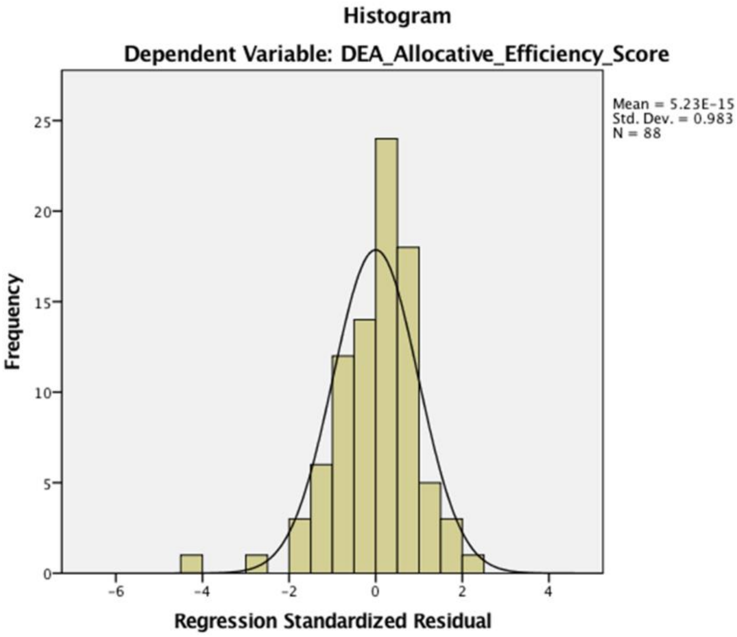
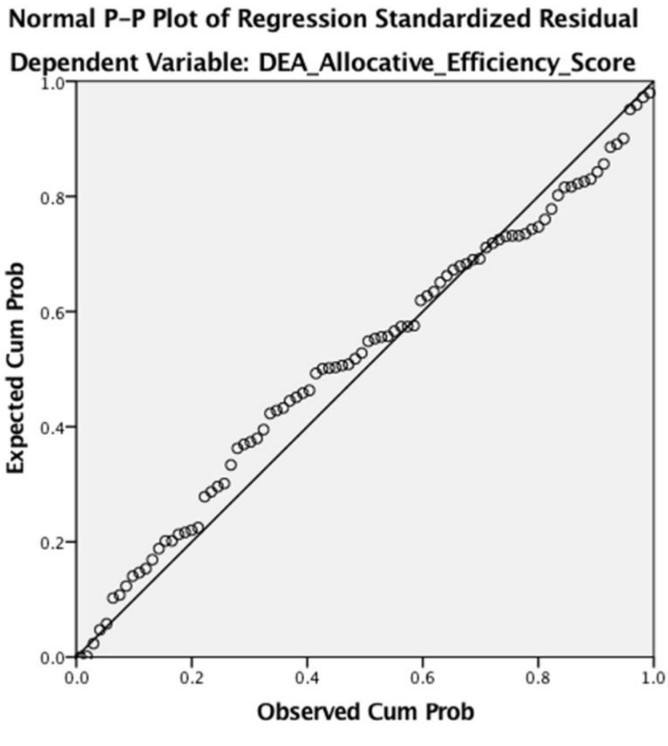


Figure A6.2D – Normal P-P plot of regression standardised residuals– Model 2b (IRSD + ATSI + Out-of-pocket Costs)



A6.3 Regression Model 3 IER + ATSI + Out-of-pocket Costs + Assisted Needs

Preliminary regression modelling with the inclusion of the IER SEIFA index included ATSI, out-of-pocket costs ALL and Assisted Needs. Results are shown in Table A6.3.1. Assisted Needs (sig .645> 0.05) in a regression model containing IER, ATSI, out-of-pocket costs is a non-significant linear predictor of the DEA Allocative Efficiency Scores. Whilst this is similar to the previous modelling conducted with IRSD and IRSAD, there appears however to be no preliminary indications of multicollinearity given the VIFs. Aligned to the previous modelling logic, two further iterations of modelling were conducted with IER:

1. Model 3a containing IER, ATSI and Assisted Needs summarised in Table A6.3.2; and
2. Model 3b containing IER, ATSI and out-of-pocket costs, presented and analysed in chapter 6 page 211. This is the preferred model for the HORSt).

Table A6.3.1 – Preliminary Independent Variable Assessment Regression Model 3 using IER as the SEIFA index

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.796[a]	.634	.616	9.52276	1.917

a. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IER

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13035.368	4	3258.842	35.937	.000[b]
	Residual	7526.679	83	90.683		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IER

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-9.143	27.442		-.333	.740		
	IER	.073	.025	.261	2.914	.005	.549	1.821
	ATSI_prop	-152.496	26.014	-.437	-5.862	.000	.794	1.260
	OO_pocket_costs_ALL	.450	.084	.378	5.372	.000	.889	1.124
	AssistNeed_prop	-39.984	86.489	-.038	-.462	.645	.659	1.519

a. Dependent Variable: DEA_Allocative_Efficiency_Score

Table A6.3.2 shows that Assisted Needs (sig .438 > 0.05) in a model with IER and ATSI is a non-significant linear predictor of the DEA Allocative Efficiency score.

Table A6.3.2 –Regression Model 3a (IER + ATSI + Assisted Needs)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.712[a]	.507	.489	10.98891	1.450

a. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IER
b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10418.523	3	3472.841	28.759	.000[b]
	Residual	10143.523	84	120.756		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score
b. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IER

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	-15.422	31.638		-.487	.627		
	IER	.103	.028	.370	3.678	.000	.579	1.727
	ATSI_prop	-145.971	29.987	-.418	-4.868	.000	.795	1.257
	AssistNeed_prop	-77.567	99.478	-.073	-.780	.438	.663	1.509

a. Dependent Variable: DEA_Allocative_Efficiency_Score

A6.4 Regression Model 4 IEO + ATSI + Out-of-pocket Costs + Assisted Needs

Consistent with analysis of the previous modelling, preliminary regression modelling with the inclusion of the IEO SEIFA index included ATSI, out-of-pocket costs ALL and Assisted Needs. Results are shown in Table A6.4.1. Assisted Needs (sig .931> 0.05) in a regression model containing IEO, ATSI, out-of-pocket costs is a non-significant linear predictor of the DEA Allocative Efficiency Scores. IEO (sig .096>0.05) in a regression model containing ATSI, out-of-pocket costs and Assisted Needs was also found to be a non-significant linear predictor of the DEA Allocative Efficiency Scores.

There appears be no preliminary indications of multicollinearity given the VIFs. Whilst the preliminary four variable model indicated non significance of IEO with the three other variables, IEO was pursued in further modelling aligned to the previous modelling logic. As such two further iterations of modelling were conducted with IEO:

1. Model 4a containing IEO, ATSI and Assisted Needs summarised in Table A6.4.1; and
2. Model 4b containing IEO, ATSI and out-of-pocket costs summarised in Table A6.4.2.

Table A6.4.1– Preliminary Independent Variable Assessment Regression Model 4 using IEO as the SEIFA index

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.781[a]	.610	.591	9.83140	2.022

a. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IEO

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12539.568	4	3134.892	32.433	.000[b]
	Residual	8022.479	83	96.656		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), AssistNeed_prop, OO_pocket_costs_ALL, ATSI_prop, IEO

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	19.562	29.872		.655	.514		
	IEO	.042	.025	.222	1.684	.096	.270	3.704
	ATSI_prop	-156.340	28.652	-.448	-5.457	.000	.697	1.434
	OO_pocket_costs_ALL	45.370	.089	.386	5.177	.000	.847	1.181
	AssistNeed_prop	-10.401	119.620	-.010	-.087	.931	.367	2.725

a. Dependent Variable: DEA_Allocative_Efficiency_Score

Model 4a presented in Table A6.4.2 shows that in this model IEO is a significant linear predictor of the DEA Allocative Efficiency Score, although Assisted Needs is not.

Table A6.4.3 shows that in Model 4b, IEO, ATSI and out-of-pocket costs are significant linear predictor of the DEA Allocative Efficiency Score. This model meets all the requirements of robust regression. The regression model itself is significant as per the F statistic in the ANOVA section. There is no indication of multicollinearity as per the VIFs. This model explains 61% of the variation in the DEA Allocative Efficiency scores, 59.6% adjusted for the number of independent variables included. Proof of this model (4b) meeting all the other regression assumptions for robust regression is now presented.

Table A6.4.2 –Regression Model 4a (IEO + ATSI + Assisted Needs)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.696[a]	.484	.465	11.24058	1.627

a. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IEO

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9948.598	3	3316.199	26.246	.000[b]
	Residual	10613.448	84	126.351		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), AssistNeed_prop, ATSI_prop, IEO

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-1.932	33.823		-.057	.955		
	IEO	.083	.027	.435	3.035	.003	.299	3.344
	ATSI_prop	-138.678	32.525	-.397	-4.264	.000	.707	1.414
	AssistNeed_prop	49.479	136.125	.047	.363	.717	.370	2.700

a. Dependent Variable: DEA_Allocative_Efficiency_Score

The Durbin Watson statistic (d) 2.026 in Table A6.4.3 is demonstrating the model exhibits no auto-serial correlations. As per the previous section as d 2.026>1.6990 (the critical value from the Durbin Watson table), the H_0 is not rejected and the residuals are independent. In addition, Figure A6.4A shows a line graph of regression unstandardized residuals. Between case numbers there is no discernible pattern of association so independence for the errors can be confirmed and therefore there is no autocorrelation or serial correlation observed.

Table A6.4.3 –Regression Model 4b (IEO + ATSI + Out-of-pocket Costs)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.781[a]	.610	.596	9.77315	2.026

a. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IEO

b. Dependent Variable: DEA_Allocative_Efficiency_Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12538.837	3	4179.612	43.759	.000[b]
	Residual	8023.209	84	95.514		
	Total	20562.046	87			

a. Dependent Variable: DEA_Allocative_Efficiency_Score

b. Predictors: (Constant), OO_pocket_costs_ALL, ATSI_prop, IEO

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	17.362	15.793		1.099	.275		
	IEO	.044	.016	.231	2.704	.008	.637	1.570
	ATSI_prop	-155.820	27.855	-.446	-5.594	.000	.729	1.372
	OO_pocket_costs_ALL	45.862	.088	.385	5.224	.000	.855	1.170

a. Dependent Variable: DEA_Allocative_Efficiency_Score

Figure A6.4A– Line Graph of Regression Residuals - Model 4b (IEO + ATSI + Out-of-pocket Costs)

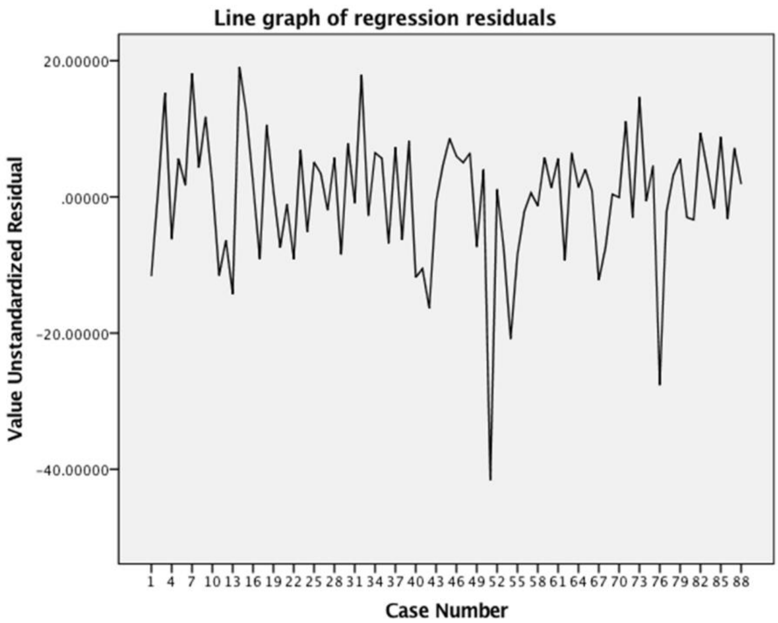


Figure A6.4B is a scatter plot that test for heteroscedasticity. There is no discernible pattern to indicate any association with standardised predicted values on the x axis with the regression residuals on the y axis so we can conclude that the model meets the assumption of homoscedasticity.

Figure A6.4C shows a histogram indicating pictorially that the residuals are normally distributed and Figure A6.4D is a graph that shows the residuals are very close to perfect normality (a straight line). It can be concluded from this that regression residuals meet the requirement of being normally distributed.

It can therefore be concluded that regression Model 4b containing IEO, ATSI and Out-of-pocket Costs ALL is a robust and parsimonious option for the HORSt regression.

Figure A6.4B – Scatter plot of regression standardised residuals versus regression – Model 4b (IEO + ATSI + Out-of-pocket Costs ALL)

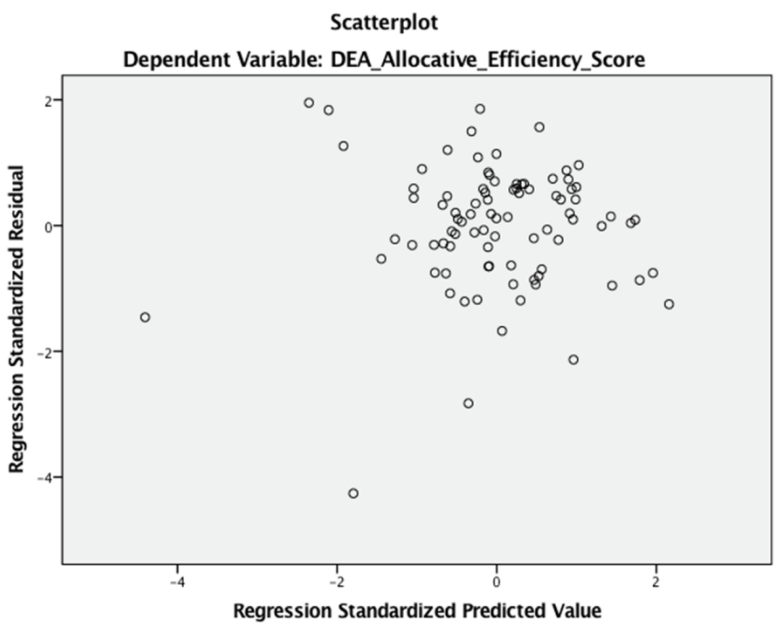


Figure A6.4C – Histogram of regression residuals– Model 4b (IEO + ATSI + Out-of-pocket Costs ALL)

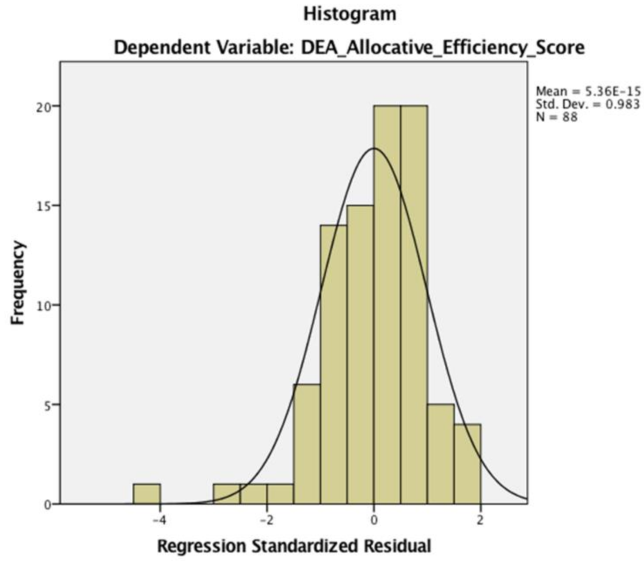
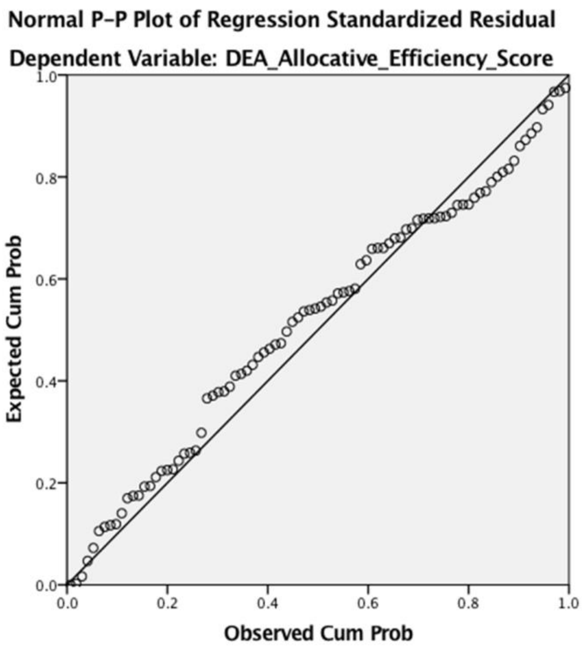


Figure A6.4C– Normal P-P plot of regression standardised residuals– Model 4b (IEO + ATSI + Out-of-pocket Costs ALL)



APPENDIX 7 SUMMARY OF KEY ASSUMPTIONS AND METHODOLOGICAL TESTS APPLIED TO THE HORST REGRESSION ANALYSIS

A7.1 Linear and additivity relationship

The outcome / dependent variable should have a significant linear relationship to the independent / predictor variables. Further, where there are multiple predictors their combined effects best describe the linear relationship when added together. Independent variables that are found to not have a linear statistical correlation with the dependent variable are unreliable predictors and require elimination from the regression analysis (Field 2013, p. 309).

The literature indicates that scatter plots can be used to assess this assumption for the individual predictors and the dependent variable (Field 2013, pp. 309-11). In addition, the Pearson's co-efficient of correlation, known as Pearson's r, provides an indication of any bivariate linear relationship with the dependent variable and amongst variables themselves (Lind et al. 2013, p. 394). Pearson's r is outlined in equation A7.1. This test shows the direction of the association as positive or negative and the statistical strength of the correlation as an absolute value between 0 and 1: 1 being perfect linear correlation; 0 indicating no linear relationship whatsoever (Babbie et al. 2018, pp. 245-6).

Equation A7.1 - Pearson's r – coefficient of correlation

$$r = \frac{N\Sigma \mathrm{xy} - (\Sigma \mathrm{x})(\Sigma \mathrm{y})}{\sqrt{([N\Sigma x^2 - (\Sigma \mathrm{x})^2][N\Sigma y^2 - (\Sigma \mathrm{y})^2])}}$$

where $N = $ *number of pairs*

$\Sigma x = sum\ of\ x\ scores$

$\Sigma y = sum\ of\ y\ scores$

$\Sigma x^2 = sum\ of\ squared\ x\ scores$

$\Sigma y^2 = sum\ of\ squared\ y\ scores$

$\Sigma xy\ = sum\ of\ the\ products\ of\ paired\ scores$

(Lind et al. 2013, p. 397).

SPSS software V24 (IBM Corp 2017) will be used with the HORSt data in Chapter Four to generate scatter plots and a matrix of bivariate correlations between potential independent variables and the dependent variable using the Pearson's R coefficient of correlation.

A7.2 Multivariate normality

In regression analysis the vertical distances between the data points and the regression model are known as residuals or errors. This is illustrated by example in Figure 14 by the distances of the blue data points vertically above and below the red regression model line. It is an important assumption for the regression that these residuals are random and are normally distributed with a mean of zero (where zero implies zero distance to the regression line). Non-normally distributed residuals can invalidate confidence intervals and tests of significance for the predictor variables (Field 2013, p. 311). Importantly it is the distribution of regression residuals that need to meet this assumption and not the distribution of the predictor variables themselves. As such SPSS software will be used to generate a histogram and normal probability plot of the regression standardised residuals. These area the standard procedures required to test this assumption (Perera 2017, p. 137).

The following examples show a histogram (Figure A7.2a) and probability plot (Figure A7.2b) when indicating multivariate normality. Figure A7.2a is indicative of a normal distribution bell curve and Figure A7.2b is indicative of the data points close to the ideal diagonal line, whereas discussed above the residuals are random and are normally distributed with a mean around zero. Both graphs will be produced for the HORSt data in Chapter Six to assess multivariate normality.

Figure A7.2a Example histogram of multivariate normality of regression standardized residuals

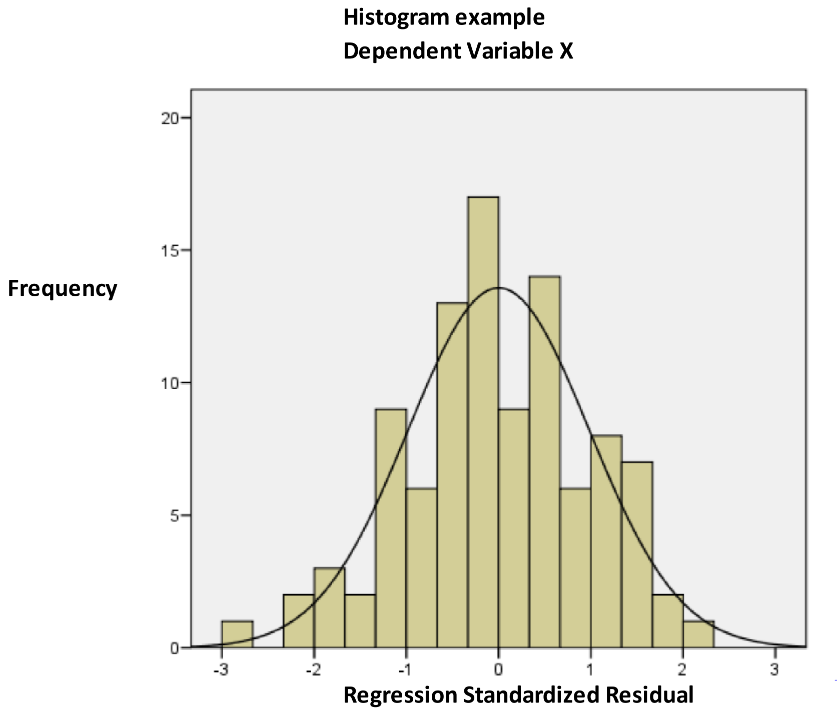


Figure A7.2 adapted from (Perera 2017, p. 141).

Figure A7.2b Example probability plot illustrating multivariate normality of regression standardized residuals

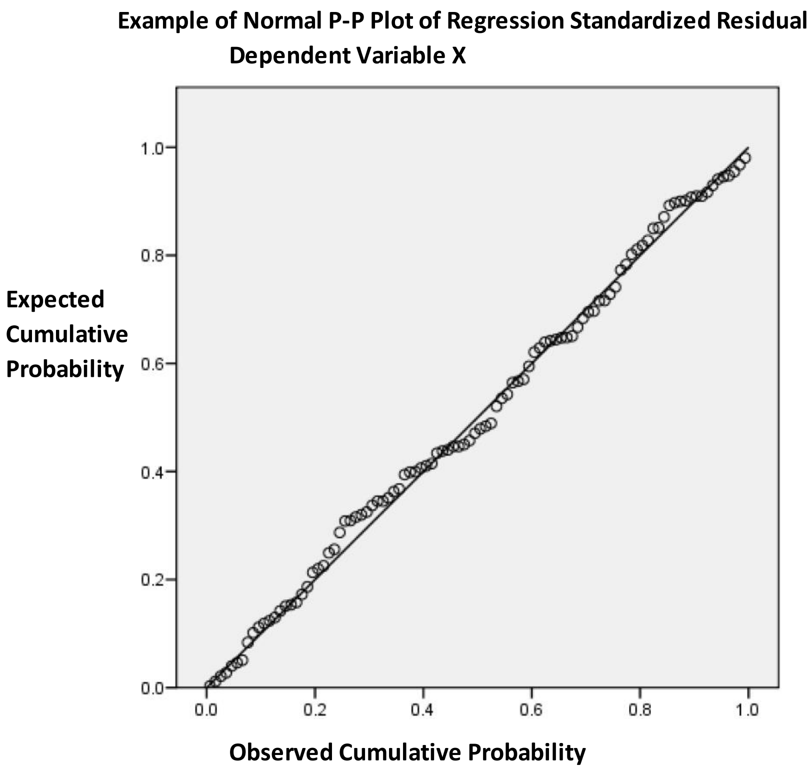


Figure A7.2b adapted from (Perera 2017, p. 142).

A7.3 No or little multicollinearity

Multicollinearity occurs when some of the predictor variables in the model are highly correlated with each other. This creates a problem in that it can become difficult to isolate the individual effect of these explanatory variables on the dependent variable. In such cases the regression coefficients for the correlated variables may fluctuate, depending on which variables are included in the regression. More seriously multicollinearity can diminish the accuracy of the coefficients, which weakens the statistical power of the regression model (Frost 2017b; Ott 1988, p. 492).

The Pearson's R statistic previously discussed, showing correlation coefficient values between 0 and 1 can logically be used to assess the correlations between pairs of independent variables, with coefficient values closer to 1 (perfect correlation) being indicative of strong correlations, with a general rule that correlations between -0.70 and 0.70 are not likely to be problematic (Lind et al. 2013, p. 466). However, a precise test, known as the Variance Inflation Factor (VIF) shown in equation A7.3 is useful in diagnosing multicollinearity.

Equation A7.3 - Variance Inflation Factor

$$VIF = \frac{1}{1 - R_j^2}$$

where R_j^2 is the coefficient of determination from a regression equation where the selected independent variable to test for multicollinearity is used as a dependent variable and the remaining independent variables are included as independent variables (Lind et al. 2013, p. 466).

According to Field (2013, p. 325) there is no precise threshold for when VIF determines a problem with multicollinearity. For example a VIF greater than 10 according to some literature is considered to be unsatisfactory (Lind et al. 2013, p. 466; Marquardt 1980; Myers 1990, p. 370), whilst other literature suggest that a VIF greater than 5 is problematic (Snee 1973), whilst less than 5 is perfectly satisfactory (Frost 2017b). Moreover, Bowerman and O'Connell (1990); Field (2013, p. 886) argue if the average VIF of the independent variables are greater than 1 in a regression multicollinearity may be biasing the model.

Hamburg and Young (1994, p. 528) assert that if a suspected collinear variable is deleted from a regression and the R^2 increases the deletion is justified. This approach will be adopted for the HORSt assessment of multicollinearity using SPSS software V24, considering the VIF values for independent variables below a value of 5 and whether or not the effect on the coefficient of determination (R^2) by considering their deletion increases.

A7.4 Homoscedasticity

This assumption requires that the spread of errors (residuals) in a regression model is constant across the range of values the regression model predicts. Homoscedasticity is required for the regression as the predictive relationship between the independent variables and dependent variable should not be constrained amongst a limited range of the independent values. If the model has an inconsistent spread of residuals that increase with the predicted values of the dependent variable, the assumption of homoscedasticity is violated and heteroscedasticity exists. The presence of heteroscedasticity makes the predictive purpose of the regression untrustworthy (Hair et al. 2010, p. 74; Lind et al. 2013, p. 465).

The HORSt regression will utilise SPSS V24 software to produce scatterplots of the regression standardised residuals and the standardized predicted values so as to map patterns in the data that can reveal whether or not the spread of the residuals increase with increases in the predicted value. Doing so is a valid test for the homoscedasticity assumption being met (Perera 2017, pp. 9/13-9/5). Figure A7.4 is an example of two scatter plots showing homoscedasticity on the left-hand side and heteroscedasticity on the right-hand side. Note that for heteroscedasticity as the regression fitted values increase the residuals increase too.

Figure A7.4 Example scatter plots of regression standardised residuals and standardized predicted values (fitted values)

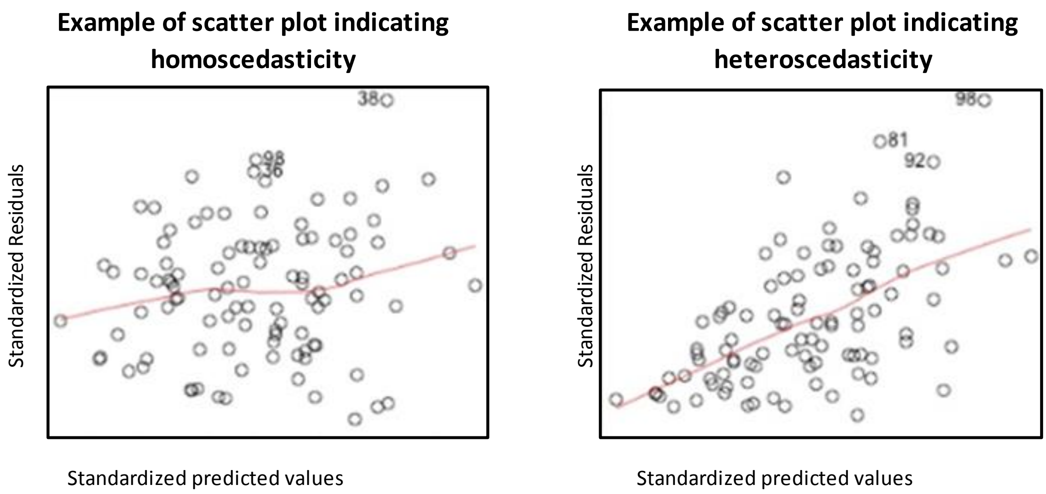


Figure A7.4 adapted from: (Analytics Vidhya Content Team 2016).

A7.5 No serial or auto-correlation

A key assumption for the regression is that successive residuals should be independent of each other (Lind et al. 2013, p. 468). If this is violated residuals may be influencing one another, causing the predictive power of the regression to be questionable (Hamburg & Young 1994, p. 529). In the case of time series data, which is not going to be used for the HORSt, auto correlation can be a significant issue, where data in one-time period may not be too dissimilar to data in the next and so forth (Berenson et al. 2013). Moreover, serial correlation can arise in non-time series data, whereby adjacent residuals are correlated (Field 2013).

There are two standard approaches to assessing whether or not serial or auto correlations are present in a regression. The first involves the use of the Durbin-Watson statistic shown in equation A7.5 and subject to hypothesis testing. The second involves analysing the pattern of unstandardized residuals to see whether or not adjacent residuals defy the assumption of independence. Both will be used to check the HORSt regression in Chapter Four using SPSS Software V24. These approaches are now outlined.

Equation A7.5 – Durbin-Watson (d) statistic

$$d = \frac{\Sigma_{i=2}^{n}(u_i - u_{i-1})^2}{\Sigma_{i=2}^{n} u_i^2}$$

$where: \; d = Durbin - Watson\ statistic$

$u_i \; = a\ residual\ from\ the\ regression\ equation\ in\ time\ period\ i$

$u_{i-1} = a\ residual\ from\ the\ regression\ equation\ in\ time\ period\ i$

(Hamburg & Young 1994, p. 529)

To understand the operation of the Durbin-Watson statistic, Berenson et al. (2013, p. 434) outline from equation 7 that:

- "the numerator, $\Sigma_{i=2}^{n}(u_i - u_{i-1})^2$ is the squared difference between two successive residuals summed from the second to nth values;
- the denominator, $\Sigma_{i=2}^{n} u_i^2$ is the sum of the squared residuals;
- where successive residuals are positively auto/ serial correlated the value of d will approach 0;

- where successive residuals are negatively auto/ serial correlated the value of d will approach will be greater than 2 or approach its maximum value of 4; and
- where the residuals are not correlated the value of d will be close to 2."

In order to interpret whether or not values either side of 2 are significant to conclude positive or negative auto/ serial correlation, or no correlation, critical values are found from the Durbin-Watson tables (Savin & White 1977) showing a level of statistical significance (α), the sample size (n) and upper (d_U) and lower (d_L) critical values (Berenson et al. 2013, p. 435; Perera 2017, pp. 131-2).

Once calculated and the tabular critical upper and lower values are obtained the Durbin-Watson statistic is used in hypothesis testing whereby:

$$Null\ hypothesis\ = H_0: Residuals\ are\ independent$$

$$Alternative\ hypothesis\ = H_A: Residuals\ are\ not\ independent$$

The determining criteria for the hypothesis testing are:

- If $d < d_L\ OR\ (4 - d) < d_L$ reject the null hypothesis, conclude that there is positive autocorrelation;
- If $d > d_U\ OR\ (4 - d) > d_U$ do not reject the null hypothesis, conclude the residuals are independent; and
- If $d_L < d < d_U\ and\ d_L > (4 - d) > d_U$, the test is inconclusive.

Note: the value of 4 above in the three criteria denotes the maximum value of the Durbin-Watson statistic.

(Berenson et al. 2013, pp. 434-5; Hamburg & Young 1994, p. 530; Perera 2017, pp. 131-2)

A secondary method for the HORSt to check for auto-serial correlation will be a simple line plot of the residuals (Perera 2017, p. 131). Figure A7.5 below which show an example where there is no discernible pattern of association between the adjacent residuals and no auto-serial correlation.

Figure A7.5 Examples of Line graph of residuals to detect auto-serial correlation

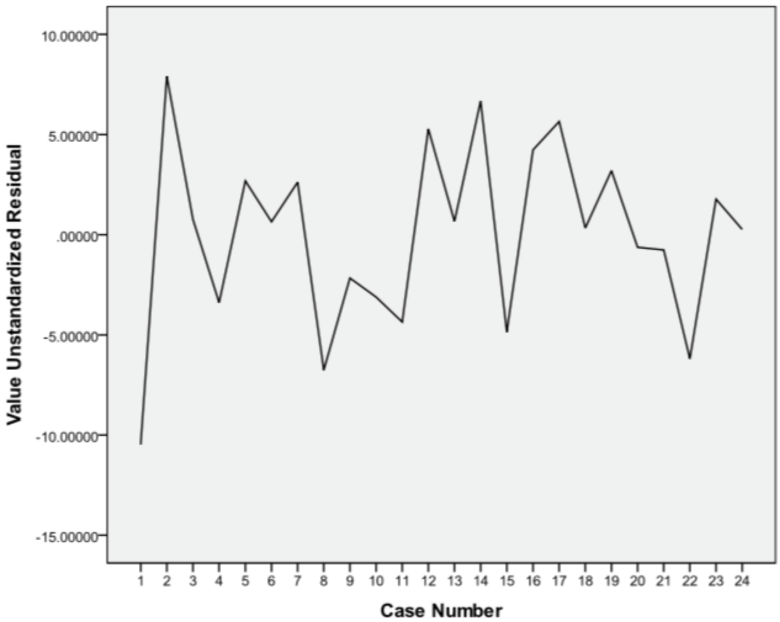


Figure A7.5, is Figure 9-14 from (Perera 2017, p. 131).